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On the Present Status of the X-Rays.*

BY M. I. WILBERT.

A short seven years ago the newspapers of the country were publishing lengthy accounts of physical experiments, that were being carried on by scientific investigators all over the civilized world. These experiments were being made with a view of proving, or disproving, if possible, the assertion of a German professor of physics, that he had made a wonderful discovery, and that he was able, by means of certain well-known physical apparatus, to take photographs of objects that were invisible to the human eye.

How slow the civilized world was to grasp or appreciate the possibilities contained in the original contribution, is evidenced by the fact that it was nearly a calendar month after Professor Roentgen announced his discovery before

* A lecture delivered before the Franklin Institute and the Central Branch Young Men's Christian Association, in Association Hall, Philadelphia, Friday, February 13, 1903.

the Physico-Medical Association of Würzburg, before any news of the same reached this country, and it was fully three weeks more before sufficient of the details were available to permit American physicists making experiments along the same lines.

Many of you will remember how, after the publication of additional reports of success, excitement and expectation ran high, the wildest and most wonderful assertions were made as to what this new form of energy really was or what it might be expected to do. A collection of newspaper clippings of the early months of 1896 would be interesting reading at the present time.

It must not be supposed for a moment that this discovery was entirely an accidental one, or made by a man whose mind had not been trained to make observations along particular lines of scientific research.

Wilhelm Conrad Roentgen was, at the time he discovered the X-rays, 50 years of age, and by far the greater number of these years had been devoted to the study of physical phenomena. In consideration of his abilities and scientific worth he had been made professor of physics at Giessen, in 1879. It will be remembered that this is the university at which the celebrated Liebig did his world-renowned work in chemistry. From Giessen, Roentgen was transferred to Würzburg in 1888, having acted as assistant here to Professor Kundt, in the early seventies. It was in the Physical Institute of the University of Würzburg, while at work on a subject that had been more or less actively discussed for upwards of eighty years, that Professor Roentgen noted that a piece of paper, coated with platinum barium cyanide fluoresced, when a vacuum tube, which he had wrapped in black or opaque paper, was excited by means of a suitable electric current. The direct cause of this particular experiment dates back to 1816, when the English philosopher and scientist, Michael Faraday, in one of his lectures, suggested that matter probably existed in a fourth state, in which it had properties as different from a gas as this is from a liquid, or a liquid from a solid. Matter in this supposed fourth state was designated by Faraday as radiant matter.

A discussion of the subsequent investigations and the controversies that arose from them would take us too far from the subject immediately before us. Suffice it to say that, following along lines of thought suggested by Faraday, a number of noted scientists have made experiments and propounded theories. In Germany, Professor Plücker, of Bonn, was able to induce the ingenious mechanician, Heinrich Geissler, to devote a considerable amount of time to the construction of those ingenious pieces of the glass-blower's art so well known to all of you as Geissler tubes.

Professor Hittorf and, somewhat later, Professor Goldstein, worked along the same lines, and it was the latter who propounded the theory that the phenomena observed when a current of electricity was passing through a vacuum tube was due to vibratory motion in the ether.

The English physicist, Mr., now Sir William Crookes, was able to construct and use tubes of very high vacuum, with which he appeared at least to be able to demonstrate that the visible phenomena was due to the movement of material particles, thus actually demonstrating Faraday's supposed fourth state of matter.

The lecture or demonstration embodying Crookes' investigations was given in connection with the annual meeting of the British Association for the Advancement of Science, at Sheffield, in 1879. In the course of this lecture Crookes failed to mention the work done along the same lines by German scientists, particularly Hittorf and Goldstein, and it was this omission, probably more than the difference in theory advanced, that caused a revival of interest in the subject in Germany.

Among others, Prof. Heinrich Herz, of Bonn, devoted considerable time to the study of the phenomena accompanying the discharge of high potential electric currents through vacuum tubes. After his death the subject was continued by his assistant and pupil, Paul Lenard; the work done by the latter investigator practically leading up to where it was taken up by Roentgen, who, while repeating and elaborating on Lenard's experiments, discovered the very interesting physical phenomena, the practical application of which we are to review this evening.

As noted before, Roentgen's attention was attracted by the fluorescence of a piece of paper coated with barium platinum cyanide. His trained mind was not slow in grasping the possibilities of this phenomena, and these he demonstrated by subsequent experiments.

It may be interesting to add here that so complete were Roentgen's researches and experiments, that comparatively little of practical importance has been added since Roentgen read his first paper. The practical application of the X-rays has been largely restricted to medicine and surgery; but in this field their usefulness has fully come up to, if not exceeded, the expectations of the early experimenters. It is true that the crudeness of the early apparatus and the careless way in which many of the early experiments were conducted brought failure, and with failure discredit and suspicion of a method so little understood, and apparently so fraught with possible dangers.

To get some idea of the improvements that have been made in apparatus and methods of technique, let us first look at these two pictures of a purse. The first was made by Professor Goodspeed, of the University of Pennsylvania, in February, 1896, and was one of the first X-ray pictures made in this city. It required an exposure of thirty minutes at a distance of 10 centimeters (about 4 inches) from the tube. The second picture, made recently, required an exposure of but three seconds, with the tube 50 centimeters, or about 20 inches, from the object.

In addition to the very decided decrease in the time of exposure, we have in the latter picture a very marked increase in detail and penetration. The two coins in the purse are sharply outlined, the seams of the leather are clearly indicated, and, in addition to this, there is sufficient penetration of the metallic objects to show the contour of the silver through the brass coin. The reasons for this improvement will be more appreciated when we come to consider the source of the X-rays.

So far as known, X-rays are produced only by the discharge of a high potential electric current in a vacuum-tube. To get the most efficient rays, however, it is necessary that the tube be of special construction.

The most satisfactory tubes available at the present time are those in which the cathode rays are focussed to impinge on a comparatively small portion of a platinum plate forming the anode. This plate then becomes the source of the X-rays.

In the early tubes the cathode rays impinged on the glass wall of the tube directly opposite to the cathode. The whole area on which the cathode rays impinged became the source of X-rays, thus distributing their origin over a large surface, thereby causing a more or less blurred image on the photographic plate or fluorescent screen.

The source of the electric energy is of considerable importance. Broadly speaking, we have two possible sources of supply—the older and perhaps less efficient generator, and the more modern and now widely used transformer.

The generator type is best represented in the well-known static machine, the forerunner of which was invented by an early German scientist, Otto Von Guericke, more than 250 years ago; it was later improved upon by Sir Isaac Newton, who substituted a glass globe for the sphere of sulphur used by Von Guericke.

The present type of influence machine was invented almost simultaneously by Holtz and Toepler, in 1864, while a modification of it was introduced by Wimshurst, and is usually referred to by that name. Static machines, as used at the present time, may be said to consist of two or more glass plates so arranged that we have alternately a stationary plate carrying the so-called armature, and a revolving plate in front of which are the combs or brushes to collect the electricity when the machine is set in motion.

This, however, while it is no doubt the simplest form of generator for an electric current of high potential, is not so uniformly reliable as is the transformer.

With the transformer we must of course have some other source of electric energy; this may be the simplest form of primary battery, or we can use the current direct, or modified in several ways, from the ordinary street-lighting plants, the latter of course being much the more economical where any appreciable quantity of current is to be used.

The type of transformer that has been used with most satisfactory results is represented by the well-known Ruhmkorff or Ritchie coils. Here, again, we cannot stop to go into details as to the construction or the comparative efficiency of different modifications of this well-known piece of physical apparatus; suffice it to say that while even the best available coil cannot be considered the acme of perfection, these coils must, at the present time at least, be considered to be the most reliable and altogether the most satisfactory source of high potential electric energy available. In addition to the Ruhmkorff type of coil, what is variously known as a Tesla, Thompson or high-frequency coil, has been used to some extent in connection with X-ray work. This type of coil, while it is perhaps more efficient as a transformer, does not give as satisfactory results in connection with the high-vacuum tube.

Among other forms or modifications of older transformers we may mention the Kinraide coil; this is practically a double induction coil; Thompson's static transformer, this being essentially a combination of Leyden jars, and Professor Trowbridge's ingenious combination of storage batteries, with which he has been able to duplicate any and all of the results obtainable with an induction coil.

We said a few moments ago that the only available source of the X-rays was by means of a discharge of a high potential electric current through a vacuum tube; this statement should be qualified by saying that this is the only practicable source of the X-rays. Early in 1896, when all sorts and kinds of experiments were being conducted with a view of finding other sources of the X-rays, Monsieur Henri Becquerel discovered that several chemical substances had the property of affecting photographic plates through opaque wrappers. A number of scientists have taken up this particular line of investigations, and the results obtained so far appear to indicate that this field offers some most interesting possibilities. Madame and Monsieur Curie have devoted considerable time to the study of what is usually referred to as radio-active matter, and they have been able to isolate several supposedly new

elements, one of which, at least, appears to have been established as a distinct and separate element. This is radium, which has just been added to the list of elements by the International Commission on atomic weights. It has been given the symbol Ra, and is supposed to have an atomic weight of approximately 225. In addition to radium, there are two other radio-active elements—polonium and actinium; while, in addition, both thorium and uranium appear to have radio-active properties.

We have this evening several pictures that were made by means of the Becquerel rays. (All of the rays produced by these various radio-active bodies are usually referred to as Becquerel rays.) These pictures were made by placing a quantity of urananite in a paper envelope, wrapping a photographic plate in several layers of opaque paper, and then placing several metallic objects between the envelope containing the urananite and the package containing the photographic plate, and allowing them to remain in contact in a dark-room for from one to ten or twelve hours. On developing the photographic plate it will be found that an image of the denser objects interposed is quite sharply defined.

So far, these Becquerel rays have attracted little attention outside the realm of pure science; and while the possibilities of their application are numerous, the scarcity and comparative high price of strongly radio-active materials has prevented any extensive experiments being made in their practical application.

A possible use for the X-rays that suggested itself at an early date was their application in time of war to locate bullets and other missiles, and in this way dispense with the ofttimes dangerous practice of probing.

These rays have been used, with very satisfactory results, in no less than four campaigns: the British Soudan campaign, the Græco-Turkish war, the American war with Spain, and also in the British-Boer war in South Africa.

In the war with Spain the X-rays were used quite extensively and with very satisfactory results. In this connection it may be mentioned that military surgeons usually ascribe a marked proportion of the decided decrease in the mortality of the injured to the judicious use of the X-rays.

The medical department of the United States Army has recently issued a very complete and exhaustive report on "The Use of the Roentgen-Ray by the Medical Department of the United States Army in the War with Spain, 1898."

The data for this report was compiled by Captain, now Major, W. C. Borden, who has charge of the X-ray work in the army hospitals.

The contained half-tone plates and pictures are particularly interesting, as illustrating the variety or kind of an injury made by the modern small-arm projectile.

Wars, while becoming more dangerous, are fortunately becoming more and more expensive and less plentiful. There are, however, quite a number and variety of accidents that are of daily occurrence and to which the X-rays are important as an additional means for determining the nature as well as the extent of the resulting injury. We cannot expect to go over the list of possible fractures, so must content ourselves with indicating just a few of those occurring most frequently, and incidentally pointing out to you several points in which injuries of this kind differ from the accounts or descriptions of them found in the older text-books on surgery.

There is a widespread popular belief that a sprain is worse than a fracture or break. The fundamental reason for this belief is illustrated by a number of pictures that we have here, which show that what is usually called a sprain is ofttimes a fracture involving one or more of the bones at or near a joint. These joint fractures usually do not involve any appreciable amount of the articulating surface of a bone, and are therefore not readily recognized as fractures by the ordinary methods, consequently are not treated as they should be. It does not require much medical knowledge to appreciate that an injury to a bone at or near a joint, not properly treated, may lead up to very considerable interference with the normal function or use of that joint. Among the portions of the body that are particularly susceptible to injuries of this kind are the wrist, elbow, shoulder and ankle; in each of these the X-rays have demonstrated fractures that formerly were not even suspected.

The proper treatment of injuries of this kind is, of course, made practically simple and easy by the accuracy and the completeness of the diagnosis. In addition to being useful as an additional means for diagnosis, the X-rays are also useful to control or to observe the progress of the subsequent treatment. After a fracture has been reduced, or set, as it is sometimes called, and the proper dressings applied, the X-rays may be used to see the exact position of the bones, whether or not they are in apposition, and whether or not the dressings have been properly applied.

The only kind of surgical dressing that interferes materially with an examination of this kind is one in which a metallic splint is used. The ordinary wooden splint, or even a plaster-of-paris cast, does not interfere materially with the penetrating properties of the X-rays.

That there is even with the X-rays a possibility of making an error cannot be denied; this possible error is however entirely due to the personal factor that necessarily enters into the making of an examination of this kind. With increased experience on the part of the X-ray operator, or possibly with the introduction of improved apparatus that will do away with the necessity of close personal attention, this possible source of error will be largely if not entirely eliminated. The X-rays themselves being a purely mechanical problem, with fixed and definite factors, the results obtained must necessarily represent the sum total of these various factors. We must pass on, however, to the consideration of other possible uses for the X-rays.

Dislocations or luxations are not always so readily recognized as one would be led to suppose. There are quite a number, partial luxations particularly, that are not easily recognized in the ordinary way, or that are sometimes mistaken for an injury or lesion of quite a different character.

We have here a number of pictures that illustrate the difficulty of making a diagnosis of a luxation, or especially of a partial luxation. If any further evidence were needed, it might be found in the newspaper reports of the clinics given by the celebrated Austrian orthopedic surgeon, Dr. Lorenz, who, when on his visit to this country, operated on

quite a number of luxations, particularly congenital luxations of the hip joint.

These congenital luxations are so persistent and difficult of treatment, simply because they are not recognized early enough. The injury, usually occurring at the time of birth, is not recognized until the child begins to try to walk. By this time the muscles and tendons have adapted themselves to the new position of the thigh bone, the normal articulation has been partially obliterated and a new or false articulation has been formed. To overcome this combination at this late day requires an operation of considerable extent, and operative skill of a very high degree; whereas, if the lesion had been recognized in time a comparatively simple procedure would have accomplished the same purpose.

Foreign bodies, particularly when they are of a substance denser than the portion of the human body in which they are imbedded, are readily recognized.

In the extremities they are easily located by taking X-ray pictures in two different directions. In the flat portions of the body this is not done so readily, and for locating foreign bodies in the third dimension, several very ingenious and more or less successful methods have been adopted. In England pictures of this kind are quite frequently taken stereoscopically; by mounting the resulting negatives so that they may be looked at in a reflecting stereoscope, a very fair idea of the depth at which the body is imbedded may be had. Another method that depends on pretty much the same principle is that followed by Mr. Mackenzie Davidson. This consists of taking two pictures of the same part from two different angles, and then, by a very simple method of triangulation, locating exactly the depth at which the foreign body is located.

Dr. William M. Sweet, of this city, has devised a very ingenious little apparatus that was designed to locate foreign bodies in the eye, but is also applicable to other portions of the body, particularly the hands and feet.

The location of foreign bodies in the gastrointestinal tract is of very great importance. Quite a number of deaths have been reported, due to injury caused by unrec-

ognized or unsuspected metallic bodies in different portions of the body.

Accidents of this kind are not at all infrequent, particularly with children, who appear to have a morbid fancy for swallowing all sorts and kinds of metallic substances, such as coins, pins and small toys. How readily these ingested foreign bodies may be located is illustrated in a series of pictures that we have here showing foreign bodies in the esophagus, the stomach and also in different portions of the intestinal canal.

The treatment of these cases is simplified and may be closely followed and controlled by means of the X-rays. Usually a foreign body will pass through the intestinal tract without doing any material damage. There are, however, cases where prompt surgical interference is indicated, and for these the X-rays are of very great use and importance, in that we are able definitely to locate the foreign body, get a very fair idea of its comparative size, and from this data judge of its probable injurious action.

Ingested foreign bodies are not as painful or as dangerous as are the collections or accretions of materials that are sometimes formed in the different abdominal organs.

The gall-bladder, the kidneys and also the bladder are frequently affected in this way. Of the three, calculi or stones in the kidneys are most difficult to recognize by the ordinary methods. The X-rays make a diagnosis of stone in the kidney a matter of comparative simplicity, particularly in the hands of an experienced or careful operator. Dr. Charles Lester Leonard, of this city, has done much original work in this particular line, and has contributed materially to establish the X-ray method of diagnosing renal calculi.

From the kidneys these calculi occasionally find their way down through the little tubes, called ureters, to the bladder. While passing through the ureter they may be the cause of intense pain; at times they are so large that they completely occlude the ureter and become firmly lodged. In cases of this kind surgical interference becomes necessary, and here again the X-rays are of value in locating the site of the

occlusion, and in this way indicating the most desirable course for operation.

In the bladder, a kidney stone may become the nucleus for a larger stone or calculi; this may go on accumulating material for years before it interferes enough with the normal function of the organ to occasion pain or discomfort. It must be remembered, however, that a kidney stone is not necessary to occasion a stone in the bladder; a number of other causes may produce the same results.

In more purely medical cases the X-rays are quite extensively used to recognize or to demonstrate pathological conditions of several of the internal organs. For examinations of this kind, where the size, location and action of the different organs is to be studied, the fluoroscope is perhaps more valuable than is the photographic plate, as by means of the former the actions and movements of the different internal organs can be observed and a considerable amount of additional information gleaned in this way.

In case a pathological lesion has been observed by means of the fluoroscope, and a permanent record of the same appears desirable, a radiograph or X-ray negative may be made. This forms then a permanent record for future reference or comparison.

In the practice of dentistry the X-rays are of value. By means of them the process of dentition may be studied as it has never been observed before, as any irregularities or abnormal features are readily recognized. In addition to this, however, even the structure of the individual teeth may be demonstrated, and in case of abscess-cavities these may be recognized and positively located.

The nature and kind of work that has been done by the dentist can also be demonstrated or shown; and in case of an accident, such as the breaking of a drill in the root of a tooth, the foreign body is readily shown and located. In extraction cases the presence or absence of a fracture of the alveolar process may be determined if thought desirable.

In chemistry, particularly in detecting adulterations of inorganic materials in drugs or chemicals of organic origin, the X-rays have been used to considerable extent and have

quite a wide field of application. Drugs like the gums, gum resins, and resins, that are rather difficult to examine in the ordinary way, are readily examined for inorganic or earthy adulterations by means of these rays. In coal, asphalt and other materials of a like character, the amount as well as the distribution of the ash or inorganic material may be determined very readily.

For the study of human, or for comparative anatomy, the X-rays offer advantages not found in any other direction.

The osseous structure of any of the vertebrates may be pictured so as to show the size, structure and relative positions of any and all of the bones composing it. In addition to this, the development of the bones may be studied at different stages in the same animal or individual, and in this way a very complete study of the formation and gradual development of the osseous structure may be made and accurately recorded. The complete anatomical structure, of the smaller animals particularly, is at times rather difficult to get at. By means of the X-rays not alone one, but a number of small animals, may be examined, so that the normal structure of the animal may be decided on with a considerable degree of accuracy.

Even the conchologist can make use of the X-rays for the study of the shape, structure and composition of shells, particularly of such as are rare or difficult to get, and which he does not care to submit to dissection.

All of these recounted uses, however important as they may appear, become comparatively insignificant when compared to the possible uses of the X-rays as a therapeutic agent.

Not long after the discovery of the X-rays by Roentgen, it was noted that after a prolonged, or even after repeated short exposures of any portion of the body to the energy emanating from a vacuum tube, peculiar secondary effects sometimes manifested themselves; these secondary effects varied from a slight tanning or reddening of the skin, simulating sunburn, to the production of a deep burn or ulcer. It was not long before experiments were being made with a view of controlling these secondary effects, and to develop,

if possible, their curative properties. It was argued that if these rays have the property of changing healthy cells, they should also have the property of bringing about a corresponding change in degenerate or diseased cells.

During the past four or five years a large number of more or less authenticated or reliable reports have been published, and at the present time the X-rays have firmly established themselves as having marked curative properties.

So far as known, the X-rays are applicable in but a limited number of diseases, and even here there appear to be isolated cases, where, for some unknown reasons, the X-rays do not act as promptly and as satisfactorily as in others. The reasons for this are no doubt to be found in the fact that medical men have not as yet been able to demonstrate the underlying causes, or the action of the X-rays on the various pathological conditions. A considerable amount of work is, however, being done in this direction, and it is to be expected that in the near future physicians will be able to say why and how this particular form of energy brings about changes in pathological conditions, and also be able to say in which particular conditions the X-rays will be of use as a therapeutic measure.

Until such time as physicians have some definite knowledge as to the limitations and possibilities of the X-rays, it will be well to be conservative in their use, with a view of avoiding any injurious after-effects from possible abuse.

In summing up the present applications and uses of the X-rays, it will be safe to say that as an additional means for making a complete and satisfactory diagnosis, in a variety of medical as well as surgical affections, this new form of energy has more than come up to the expectations of those most interested, and bids fair to be even more satisfactory in the immediate future.

For technical or applied scientific purposes they have probably not developed along the lines in which it was at first expected they might find application; but even here they have found uses, and these uses are constantly increasing.

As a therapeutic measure for the relief of suffering and

the cure of a number of chronic and usually discouraging conditions, they bid fair to eclipse in usefulness and applicability any one curative agent that has been added to the armamentarium of the physician for a decade at least.

No attempt has been made here to even indicate the effect that the discovery of these rays has had, both directly as well as indirectly, on purely scientific theories or investigations. Suffice it to say that they have materially broadened the horizon of positive scientific knowledge, and have in some cases shattered theories that were considered wellnigh unassailable.

In conclusion, just a few words as to the man to whose acumen, scientific training and pioneer work on the borderland of the great unknown we are indebted for much of that meager knowledge that we possess of the X-rays at the present time.

Wilhelm Conrad Roentgen was born on March 27, 1845. After the usual preliminary education he attended lectures at Utrecht and later at Zurich, where he obtained his doctor's degree in 1869. He appears to have been a favorite student with Professor Kundt, and the following year, when that professor assumed the chair of Physics at Würzburg, young Roentgen went with him as his assistant. In 1873 Roentgen went with Kundt to the University of Strasburg. Two years later he was made lecturer on mathematics and physics at the Agricultural Academy in Hohenheim. The following year he was back at Strasburg, and in 1879 he was made professor of physics and director of the physical institute at Giessen.

From here Roentgen was transferred to the University of Würzburg in 1888, where, on November 8, 1895, he made the discovery that has made his name familiar throughout the civilized world. After the announcement of this discovery he was knighted by the King of Bavaria, who also offered him the professorship of physics in the University of Munich, which he now holds.

Roentgen has received recognition, medals and honorary memberships from scientific societies all over the world.

Among the acknowledgments of a more practical nature

that he has been the recipient of, it may be well to say that in 1901 he was awarded the Nobel prize instituted by the late Alfred Bernhard Nobel, the inventor of dynamite, for the most important invention in the domain of physical science.

Altogether it may be said that the active life of Professor Roentgen has been one of close application to the exacting details of his chosen branch of science, and the merited recognition he has received for making what appears to be indisputably his discovery but illustrates that the world, after all, is quite willing to reward patient, honest workers who are willing and able to demonstrate that they are capable of doing something that no one else has done before.

STEAM TURBINE INSTALLATION.

A unique steam turbine installation is about to be made at the Cumberland Mills, Portland, Me. Most of the current for the present electric drive is supplied by a water-power plant, and the balance by a steam-power plant. The new steam turbine will be used for relay purposes, trouble being sometimes experienced with the water-power system, due to irregularity of water-supply. The turbine is 540 horse-power, taking steam at 165 pounds pressure, after it has traversed the distance of 350 feet separating the boiler-house from the engine-house. Before entering the turbine the steam will be superheated about 100° F. by means of an independent superheater, fired by waste hydrogen gas rising from electrolytic baths used in the process of manufacturing at this plant. The gas has heretofore been a waste by product. The steam "economy" will be about 13·5 pounds per electrical horse-power hour, which means about 11 pounds per indicated horse-power hour.—*Iron Age.*

FRENCH LAW OF EMPLOYER AND EMPLOYEE.

A law still obtains in France, under which any workman who divulges information regarding a secret process practised in any industry, to a foreigner, or even to a Frenchman resident abroad, commits a penal offense, and for such is liable to a sentence ranging from two to five years' imprisonment and a fine from $100 to $4,000. He is furthermore subjected to from five to ten years' police supervision after his release from jail. Even the communication of such information to another Frenchman resident in France is punishable though the sentence in this case is not so severe, the sentence varying from three months' to five years' imprisonment, accompanied by a fine ranging from $3 to $40. On the other hand, a French employer is entitled, without reserve, to any invention or discovery made by a workman in his employ that is within the scope of the work undertaken at the factory —*Scientific American.*

About Some Important Polar Navigations to High Latitudes.*

By Dr. Arnaldo Faustini.†
Translated from the Italian by Edwin Swift Balch.

The question of an open polar sea dates back to long before our time.

It occupied the thoughts of the oldest cosmographers, philosophers and mathematicians, especially those of the

* Published in "In Giro pel mondo," II, Bologna, August and Sept., 1900.

† Dr. Faustini, of Rome, is the author of a number of valuable papers about the Arctic and the Antarctic. Among them may be cited:

Sugli approdi alle regioni polari antartiche.—"Rivista Marittima," 1898.

Alcune altre osservazioni sulle "appearances of land" nella zona polare antartica.—"Bolletino della Societa Geografica Italiana," 1898.

Esplorazione dell' oceano Australe, Viaggio del Valdivia.—"Rivista Marittima," 1899.

Risultati generali della spedizione antartica Belga.—"Bolletino della Societa Geografica Italiana," 1900.

Il ritorno della spedizione polare di S. A. R. Il Duca degli Abruzzi.—"Societa Geografica Italiana," 1900.

L'Italia e le prossimi spedizioni polari Antartiche.—"Rivista politica e letteraria," 1900.

Alcune osservazioni sulla crociera dell Hertha.—"Bolletino della Societa Geografica Italiana," 1900.

Alcune considerazioni sulla meteorologia delle regioni antartici.—"Rivista Marittima," 1901.

Un tipo caratteristico di ghiacciaio antartico.—"Rivista di Fisica, Matematica e Scienze Naturali," 1901.

Di una scoperta polare australe nel 1599.—"Rivista di Fisica, Matematica e Scienze Naturali," 1901.

La Groenlandia del Sud.—"Bolletino della Societa Geografica Italiana," 1901.

Una Questione Artica.—"Rivista Italo-Americana," 1902.

Un Viaggio alle Spitsbergen nell Anno 1671.—"Rivista di Fisica, Matematica e Scienze Naturali," 1902.

I primi resultati della spedizione antartica svedese.—"Rivista Marittima," 1902.

I risultati scientifici della spedizione antartica belga.—"Rivista Marittima," 1902.

La Groenlandia.—"Rivista Italo-Americana," 1902.

Alcune Idee religiosi degli Eschimesi, Rome, 1903.

Sulle Ultima spedizioni polari artiche.—"Rivista Marittima," 1903.

—(*Translator.*)

seventeenth and eighteenth centuries, who, with an infinite number of original and fantastic theories for and against it, acknowledged or denied its existence, according to the accounts which the whale fishermen gave when they returned to their native lands with valuable cargoes which fetched big prices.

However, the theory of a perfectly open sea was that accepted by the majority, as the accounts that the mariners gave had all the appearance of being true (the reader will not forget that in the past centuries the accomplishment of great enterprises gave to many persons an authority in speaking), and for certain facts, which could not then be explained, people were rather inclined to accept as valid and to believe the queer and fervid accounts about the mysteries of the northern regions, just as to-day the descriptions of Parry and of Nansen carry an inexplicable and eerie fascination.

Moreover, not only were people in those times thoroughly alive about the problem of the existence or the non-existence of an open sea at the pole, but there was also the desire to find and to see the pivotal point of the terrestrial axis, as well as to verify how much truth and exactness there was in the unbridled conceptions of the most ancient cosmographers and philosophers.

I have said that some facts, then unexplainable, tended to back up the theory of a vast icy ocean occupying the extreme northern zone of our planet. Some Dutch fishermen had seen and caught whales, which undoubtedly had been harpooned near Davis Strait, in the regions of Spitsbergen; and Paul Egede, the bishop and the last and greatest missionary of the Danish settlement in Greenland, relates, among other things, that in 1785 a dead whale was found floating in the waters of Baffin Bay bearing in its side a harpoon stuck there two days before in the neighborhood of Spitsbergen by the brother of the whaler who picked up the dead animal. Again, Witzen writes that a mariner of Zealand, Benedictus Klerk by name, whom he knew personally, related to him how he had killed whales on the eastern coast of Korea with harpoons stuck in their sides,

showing that they had been chased by Dutch fishermen in the North Atlantic. These, and still other facts, discredited considerably in those times the theory of a sea eternally closed with ice, and, on the contrary, gave weight to the opposite opinion. Neither party, however, knew then of the great and wonderful marine circulation, due to the not less wonderful currents, powerful rivers of the sea, which, from the day of their discovery, solved a considerable number of physical, dynamic and meteorological problems.

That which to-day would be explained and which was explained by many facts depending on the submarine currents over which the ice has no power, at that time was accounted for by the theory of an open sea, with wave and tide movements similar to those of the Mediterranean, the Atlantic and other known surrounding seas. Everyone knows the theory, which has become axiomatic, that permitted Dr. Nansen to accomplish fairly successfully his last great polar exploration on the Fram, giving himself up entirely to the mercy of the current which was surmised to cross the north polar regions, at least within a few degrees of the pole, and which revealed its existence by having carried objects and relics belonging to the unfortunate Jeannette of the American expedition (sunk in the neighborhood of the New Siberian Islands) to the western coast of Greenland, near Julianeshab.

One can credit with certainty to Gerard Mercator the priority of conception of a polar sea, or rather polar abyss, which the geographer Jacques Knoyen, of Bois le Duc, was the second to describe in a strange and fabulous narrative. The critic Raemdonck, in writing about the life and the works of the celebrated German geographer, adds that nothing more fantastic was written in medieval times about the polar regions, although by a letter of Mercator himself to Johann Balak, another illustrious geographer of those times, dated from Arusburgi ad Osselam fluvium, 20 Februaris, 1581 (that was after he had left Louvain and Duisburg in the province of Clèves), we learn that the study of the polar regions had occupied him actively and deeply during the greater part of his scientific career. In fact, we

owe to Mercator a strenuous and pertinacious defense of the existence of a northeast passage, for in one of his letters to Hakluyt we find that he says: "Beyond the Islands of Waigatz and of Novaya Zemlia there is a large gulf, which has on the east the famous promontory of Tobin (perhaps the cape and peninsula of Taimir), and near it large rivers empty which must undoubtedly irrigate the interior of Cathay and Sericana, and by means of which one can enter into those countries. This gulf freezes early each year."

Moreover, Mercator wondered whether in those places the tide always came in from the same side or whether it came in sometimes from another, whether it rose or descended six hours towards the east and six hours towards the west, and finally he put definitely, resolutely an end to the question of the possible separation between Asia and America (at the time when Abraham Ortelius doubted still whether America was surrounded by water or whether it formed at the northern extremity a single and vast continent with Asia) by marking on his chart a strait which he called Anian, a strait which, from a theoretical conception, became a known fact in 1648, at the time when the Cossack Deshneff saw the Arctic and Pacific Oceans mingle.

However, the theory of an open sea remained still in a rather indefinite condition and was accepted only by a few geographers and their disciples, and it was not until the year 1614—precisely the year in which, under the wise direction of a certain Wilhelm Van Muyden, the so-called Company of the North was founded in Holland—that these legendary tales became widely spread among the public and that it became necessary to give credence to the bold narrations of the wonderful expeditions to the north of the mariners, and especially of the Dutch mariners, which they told on their return from the annual seal and whale fisheries.

In the petition presented by the members of the Company of the North, Belgians, Biscayans, Flemish, English, etc., to the Government of the States General, they gave rather clearly the proof of the existence of the open sea which some of those very members of the Company had cruised on, saying:

"A number of vessels have visited regions where no Christians have been before us; they have passed 83° of north latitude, where these ships always had around them an open sea, free from ice and from pasture lands." (*Met eene quantiteit schepen alwaar nooit christen mensch outrent hadt gewest; ja dat zy hadden gepasseerd 83 graden alwaar haare schepen geronden hadden eene ruyne zee, zonder ys, vlak weidland met graseetende gedierte.*)

Many years after, that is in 1660, a few log books were presented to the Government of the States General by the same Company of the North (whose palmy days were on the wane; their brightest period was from 1614 to 1641), with the object of arousing the interest of the Government anew, and these were in accord in affirming that on August 1, 1635, observations were taken in 86° 56′ north latitude of an open sea and a very strong tide.

We have in chronological order:

1610: The first indication of an aim towards the Arctic pole appears in 1610, four years before the Dutch presented, as we have seen, to the Government of the States General their petition for the foundation of a company for the monopoly of the whale fisheries, when there were rumors of ships being pushed beyond the 83d parallel. In 1617, the congregation of whalers to the north of Spitsbergen was so great that it was necessary to erect a factory, the factory of Smeeremburg [Blubbertown], to serve as a station for provisions and for supplies that might be needed by mariners and their ships during the fishing season. The colony and the ship-station were established on the eastern coast of Amsterdam Island (a little north of Danes Island, the site of the tragic departure of the engineer Andrée) in 75° 45′ north latitude, and in a short time it became so important that, as the chronicle of that time relates, "the bakers announced that, as in their mother country Holland, customers could be furnished with bread just out from the oven."

In 1634 (that is the year after the failure of the attempt to colonize in the North on a large scale, conceived by a certain Jean Seghers of Bruges) the number of Dutch ves-

sels occupied in those regions in whale fishing was enormous. They numbered more than 500 ships, with over 20,000 men, and Zorgdrager relates about 120 Hamburg ships which captured in one season 1,252 whales that were sold for about 500 pounds sterling apiece.*

In 1636: It was in this year, as is related by Forster,† that "a ship was dispatched [from Holland] to Greenland for the purpose of fetching train-oil, which used to be manufactured in *Sewerenberge* [Smeeremburg]; but there being not a sufficient quantity ready to complete the full lading, the captain, finding the sea quite open, sailed strait [*sic*] on to the northward, and at the distance of two degrees from it [the pole?] went twice round it. This he used to relate publicly, and to refer to his crew as witnesses of the fact. Vid. Zorgdrager's *Greenland Whale-Fishery* (German), Vol. II, chap. 10, page 162. Wood also, as he himself informs us, was told by Mr. *Joseph Moxon*, in 1676, that being in Holland about twenty years before (consequently in 1656), he had heard a very respectable Dutch captain of a ship say that he had navigated under the very pole, where he found the weather as warm as it used to be at Amsterdam in summer."

Whoever wants further particulars regarding this voyage can find them in the collection of important marine undertakings of Harris, Vol. II.

1656: In this year another Dutch ship claims to have reached 89° north latitude. "In fine, Captain Goulden likewise, who had made upwards of twenty voyages to Greenland, told King Charles the Second that, being about twenty years before in Greenland,‡ he found himself with two Dutch Greenland navigators near Eges Island, to the east-

* "Pesca alla balena al Groenland," Vol. II. (In German.)

† Forster, John Reinhold: "History of the Voyages and Discoveries Made in the North." Dublin, MDCCCLXXXVI.

‡ Let the reader bear in mind that the Arctic geography and cartography of the seventeenth century makes no distinction between Greenland and Spitsbergen, since these two lands were believed to be one and to be united across the polar cap to the north of America, in about the position of the Parry Islands.

ward of that country, when, no whales appearing near the shore, the two Dutch captains resolved to sail farther on towards the north, which in fact they did, and a fortnight afterwards returned, and related that they had been as far as the 89th degree, and had met with no ice, but with a free and open sea, with large and hollow waves, as in the Bay of Biscay. The variation of the compass there was 5 degrees. One of these captains afterwards happened to go to England, when Captain Gould [*sic*] took him to some of the members of the Northern Company, whom he fully convinced of the truth of his relation. Vide *An Account of Several Late Voyages and Discoveries.* London, 1711, p. 145; as also *The Hon. Mr. Boyle's History of Cold.*"* We have an argument in defense of this rather mythical subject by G. Gauthier, general inspector of foreign affairs in Italy, in a note of his directed to the Manager of the "Biblioteca of Milan" (relating to an account written in January, 1828, about the voyages of Parry), in which he tries to vindicate the claims of some sailors who have gone much beyond the latitude reached by Parry himself (82° 45′). Gauthier, who bases his letter upon notes taken from Forster, concludes that he knows that the narratives of the mariners have been much embellished, but that he could not consider assertions as wholly inaccurate when they seem to him so circumstantial and so positive.†

1660: According to Carlo Amoretti, who illustrated and commented upon the voyage of Lorenzo Ferrer Maldonado,‡ a certain Captain David "Melguer is said to have left Japan with his ship *Lo Padre Eterno* on the 16th of March, 1660, and to have sailed along the coast of Tartary, till he came to the 84th deg. of N. lat., and then to have shaped his course between Spitsbergen and Old Greenland, and so

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* Forster, John Reinhold: "History of the Voyages," etc., page 427. Daines Barrington, in "The Possibility of Approaching the North Pole," page 37, gives an almost similar account.

† *Bulletin Soc. de Géographie de Paris*, January, 1828.

‡ "Voyage de la Mer Atlantique à l'Océan Pacifique par le N. O. dans la Mer Glaciale," par le Capt. Laurent Ferrer Maldonado, etc., Plaisance, Del Maino, 1812.

sailing to the west of Scotland and Ireland, to have at last entered the harbour of Oporto." *

1754: Daines Barrington, author of a history of Arctic voyages, writes, on the testimony of the schoolmaster, John Adams, of Essex, that a certain Captain Guy from that country, who reached, on board of the whaler Unicorn, the 83d degree of north latitude, on his last but one journey (his fifty-eighth) some months before, had reached the 84th degree.

1766: Dr. Hamel, also the author of some important works, asserts, on the other hand, that the nearest point to the pole undoubtedly reached up to his time, was the one attained by Captain James Bisbrown, who started from Liverpool in 1765 and who arrived at 83° 40′ of north latitude with a still open sea; whilst at the same time Barrington writes that Captain Wheatley had surpassed Bisbrown in 1675 by about 5° 30′.†

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* Forster, John Reinhold: "History of the Voyages," etc., pages 464, 465. Forster continues, however: "This is the most material part of this relation, which, however, deserves no credit; for since the years 1637 and 1638, the Portuguese and Spaniards have been absolutely banished from Japan and that forever. How then was it possible for a Portuguese ship, twenty-two years after that period, to sail from Japan, a place where this nation was no longer admitted nor suffered? This consideration alone is sufficient to prove that the whole account is a mere rumor, and a story trumped up by some sailors, devoid even of the least shadow of probability arising from internal evidence."—(*Translator.*)

† In "The Possibility of Approaching the North Pole," Barrington says Jonathan Wheatley's highest latitude was 81° 30′. On page 61, Barrington gives the following list of latitudes reached by navigators:

"Captain John Reed, 80° 45′.

"Captain Thomas Robinson (for three weeks together), 81°.

"Captain John Phillips, 81° odd min.

"James Hutton, Jonathan Wheatley, Thomas Robinson, John Clarke (four instances), 81° 30′.

"Captain Cheyne and Thew (two instances), 82°.

"Cluny and David Boyd (two instances), 82° odd min.

"Mr. George Ware, 82° 15′.

"Mr. John Adams and Mr James Montgomery (two instance), 83°.

"Mr. James Watt, Lieutenant in the Royal Navy, 83° 30′.

"Five ships in company with Hans Derrick, 86°.

"Captain Johnson and Dr. Dallie (two instances; to which, perhaps, may be added Captain Monson, as a third), 88°.

"Relation of the two Dutch masters to Captain Goulden, 89°.

"Dutch relation to Mr. Grey, 89° 30′."—(*Translator.*)

1775: The Hollander Cornelis Rule is supposed to have reached a spot between 84° 30′ and 85° north latitude, where he discovered an archipelago, along which he sailed for ten miles, and beyond which he found a vast extent of open sea, so that if he had not been short of provisions he could have sailed several degrees more towards the north.

1786: The above cited Carlo Amoretti writes again that a certain Wiarth had reached the 89th degree of north latitude, where he found land and an active volcano.

1816: In the *Bulletin de la Société de Géographie de Paris* (October, 1827), one reads that in the year 1816 the whaler Neptune reached 83° 20′ of north latitude.

In an account given in the *Literary Gazette* of London (1825), it is stated that an English whaler, towards the end of the year 1824, approached the pole to within less than 1°, and discovered a coast where there were geysers of hot water in action, at some of whose rims there were flames sufficiently intense to ignite paper.

A last fantastic instance *sui generis*, occurred in 1894, and the matter was circulated in newspapers all over the world, arousing an immense amount of speculation and conjecture. This was that the American whaler Newport had reached in an open sea the 84th parallel of north latitude. Prof. George Davidson, however, not only interviewed the commander of the fortunate ship, but examined the log book, and he was able to deny the erroneous report which circulated for some time. The error arose in transmission, since instead of writing 73° and odd minutes of north latitude, 84° of north latitude was written.

Moreover, these are not the only instances which could be cited; there are many others.

Dr. Dallie gave a report of a ship which reached 88° north latitude. Mr. Miller, in his "Gardener's Dictionary," wrote about a Captain Johnson having, during a voyage to Greenland, a thermometer which registered "a degree of cold in 88° of north latitude."* Read relates that the Dutch

* See Daines Barrington: "The Possibility of Approaching the North Pole Asserted," New York, 1818, pages 44–46. Barrington makes here what appears to be an unintelligible attempt to explain an absurdity, namely, that

Captain Hans Derrick, during a whaling cruise in company with five other ships of the same nationality, undoubtedly reached 86° in a sea only slightly covered with pieces of floating ice. Finally, Buffon himself, in his "Natural History," basing his conclusions on the authority of Dr. Hickmann, member of the Royal Society in 1730, asserts that the voyage narrated by Captain Moxon is true.

And now we continue:

There may be something true and exact in the accounts given by the whaling captains of the marvelous voyages made in the waters of the extreme north.

We cannot vouch for the authenticity of the facts; but, at any rate, one of the greatest geographers of our time, Petermann, has written that the Dutch traditions of these polar expeditions (at which Admiral Osborn laughs, ridiculing them as the result of Amsterdam dreaming, backed up by strong Dutch beer) are to be accepted in more than one respect.

We return to our point, observing that such traditions—especially the first ones—were handed down verbally to our ancestors from mariner to mariner, from Dutch fisherman to Russian fisherman, from Russian fisherman to Norwegian fisherman, and so on, and that among all those stories there were only some which were reliable, and that the best of these were collected and published by some of the chroniclers and the scholars of the time, who sought in this way to confirm the theory of the open sea. And it is an error, if one may use the term, of the illustrious Gotha geographer to have too strenuously defended his opinions about the existence of a polar sea free from ice, founding his belief partly on the medieval legends of these navigations to high latitudes, where, we say again, the sea, the holy sea, as Muller* calls it, was said to have a wave and tide movement like that of the Bay of Biscay, and where the air was said to be so balmy that one might imagine one's self in Amsterdam during the summer season.

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because a thermometer marked a certain degree of cold, therefore the navigator must have reached 88° of north latitude.—(*Translator.*)

* "Sammlung Russischer Geschichten," Vol. III, chap. i.

And if one remembers that the number of Dutch, Hamburg, Bremen, Biscayan and Norwegian vessels sent to fish for whales between 1614 and 1750 was enormous, and that among the hundreds and hundreds of captains and shipmasters there may have been a few of easy conscience who did not mind drawing the long bow on their return home, it seems possible that some of their contemporaries may have doubted their accounts. It is easier to-day, in the strong and searching light of modern criticism, to sift the exaggerations from these tales and to account for the fantastic conceptions which gave birth to the ideas of an austral land and of a northwest passage which sprang from voyages such as those reported of Bernarda and of Lorenzo Ferrero Maldonado that l'Amoretti so warmly and so blindly defended.

Moreover, there is evidence of the strongest kind which helps us in forming an opinion, and that is, that these accounts would indicate a physical condition of the polar regions exactly the reverse of that which the more exact and thoughtful observations of modern navigators have shown existed. And even granting that the fascination of the marvelous had no influence on the minds of those mariners of long ago, and even admitting also that those sailors knew how to use the instruments which had been entrusted to them by the company to which they belonged, yet one can still reasonably suppose that they may have made mistakes in their calculations about the positions they thought they had reached, the more readily that the nautical and astronomical sciences of that time were very imperfect and left much to be desired.

On this matter, also, I think it opportune to quote what Malte-Brun writes in his learned introduction to the splendid collection of the "Nouvelles Annales des Voyages":

"It is easy to understand how mariners may in good faith think that they are in higher latitudes than they have really reached. Let one think of the extreme irregularity of all the movements of the magnetic needle in those seas; let one consider that one of the magnetic poles of the world may be placed so that at 80° of latitude the needle points

straight *to the south;* let one remember also the small geometric value of each degree of longitude, the convergence of the meridians, the extreme difficulty of observing the distances of the circumpolar stars, supposing that one is sailing straight ahead; let one reflect on the oblique position of the sun, if one sails by day; let one add to it the still little known effects of horizontal refraction; and one will probably admit that beyond the 80th degree even an expert sailor would have much difficulty in knowing precisely where his ship was. What then would be the situation of the navigator who had arrived under the pole itself?

"The ordinary indices of the art of navigation would be wanting for him to guide himself by; all the points of the world would be equally *to the south* for him; nothing would teach him how to make his way either to the east or to the west; the first steps, on whichever side he made them, would be done at hap-hazard; in a word, he might come back from the pole without knowing exactly if he had been there. Let one judge, then, of the amount of credence to be attached to those masters of whaling ships, who pretend to have sailed around the pole or to have been 2° beyond the pole!" *

As the reader can see—to make use of an expression not at all scientific, but very much to the point—the illustrious father of French geographers takes the bull by the horns and simply settles the question.

And now, when one brings together these four coefficients: the epoch, the fascination of the marvelous, the ignorance in the use of instruments, and the imperfection of the instruments themselves, one can and one must admit that some of the relations of journeys to very high Arctic latitudes, like the ones cited as examples, are vulnerable in almost every respect, and that, as Gauthier and Petermann write, even if there is some truth and accuracy about the stories, yet that they are too marvelous to bear close inspection.

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* Coup d'œil sur les découvertes géographiques qui restent à faire, etc.: "Nouvelles Anna'es des Voyages," Paris, Tome I, 1819.

Sulphur-Dioxide and the Binary Engine.*

By R. H. Thurston.

The "binary-vapor heat-engine," in its latest form, as illustrated by the machine employed at the Charlottenburg *Hoch Schule*, exhibits more clearly the advantages of the system than has any such apparatus previously reported upon, and the record produced under most satisfactory conditions is lower than was ever before known in the history of the economics of the heat-engines. Its consumption of steam, as a minimum, is reported as 8·36 pounds per horse-power-hour, 3·8 kilograms of moderately superheated steam, less than 9,500 B.T.U., or about 2,380 calories.† The power obtained was increased above one-third by the addition of this secondary system to the steam-engine and the economy was improved about 25 per cent. A gain of 20 per cent. was effected by the employment of superheated steam. The primary was a steam-engine of excellent construction and performance, having a "water-rate" of but about 11 pounds. These circumstances make it necessary to look upon the series-vapor engine much more seriously than has been customary. Such unquestionable economical advance must be carefully studied to ascertain whether the system can be made a commercially successful competitor of the common forms of heat-engine.

One of the first steps in such an examination of the case is the investigation of the scientific features of the system and the determination of the thermodynamic properties of the secondary fluid. As to the first of these questions there is no difficulty. The fact that the reduction of the lower limit of temperature of the heat-engine cycle is of more promise than an equal variation in the opposite direction at

* Presented to Section B, A.A.A.S., Washington Meeting, 1902.

† "Series-Vapor and Heat-Waste Engines," *Jour. Frank. Inst.*, R. H. T., October–December, 1902.

the upper limit was shown by Carnot, who asserted, seventy-five years ago, that

"*La chute du calorique produit plus de puissance motrice dans les degrès inférieurs que dans les degrès supérieurs.*" *

The second question, that regarding the relations of pressures, volumes and temperatures of the fluid, at the comparatively low temperatures of the exhaust-steam and the condenser, is settled by experience already had in the practical operation of the secondary engine employing the vapor. It gives high-working pressures at the temperatures at which it receives and discharges heat within the low and narrow range permitted its cycle when employed thus as a secondary. Steam at these lower ranges, while perfectly capable of providing 30 per cent. more power than is actually obtained from it in ordinary constructions, yields that power at so low an absolute pressure and at such a small mean pressure that it is quite unavailable in so cumbersome a machine as would be needed to develop it. It would require so large a proportion of its work to actuate the engine itself that its power-product would not be profitable. With the high mean pressures of the sulphur-dioxide vapor, the power developed is available in paying quantities.

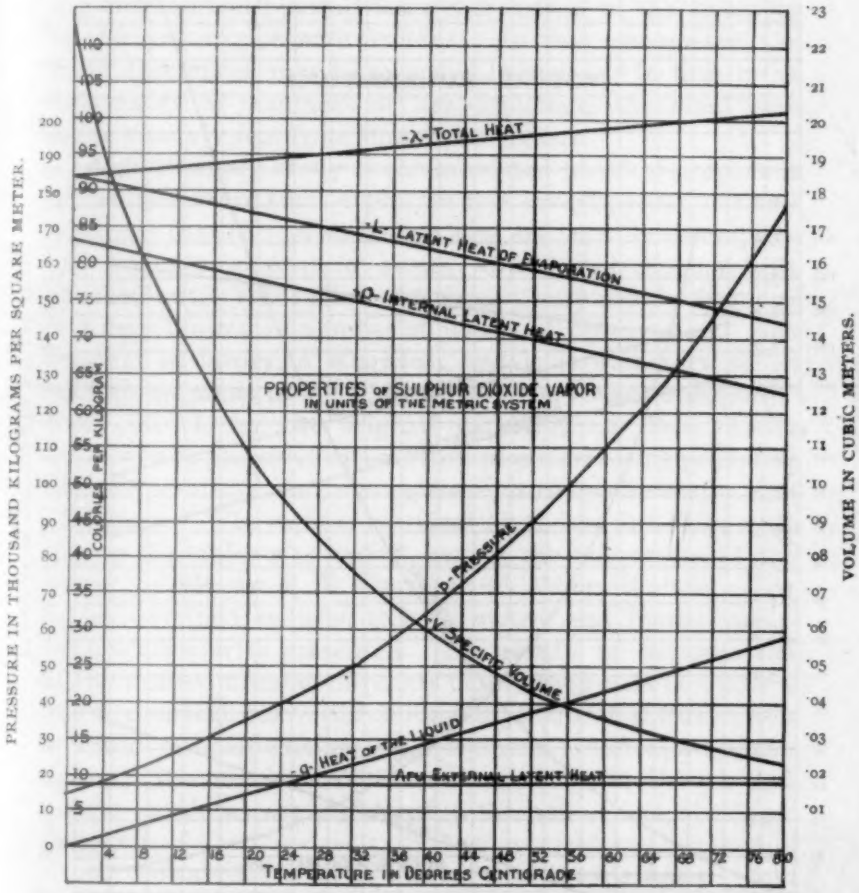
The question whether it will be practically possible to continuously employ this system as a commercial and profitable improvement upon the single-vapor engine must be settled by long experience under a great variety of conditions in regular business. The risks involved in handling the vapor, the wastes and costs of fluid, the disagreeables and the inconveniences, must all be more or less thoroughly evaded and extinguished. It is claimed that this has been accomplished. We shall know with certainty in due time.

The thermodynamic properties of the substance have not been fully investigated, and it will be interesting to ascertain just what advantage, if any, this substance has

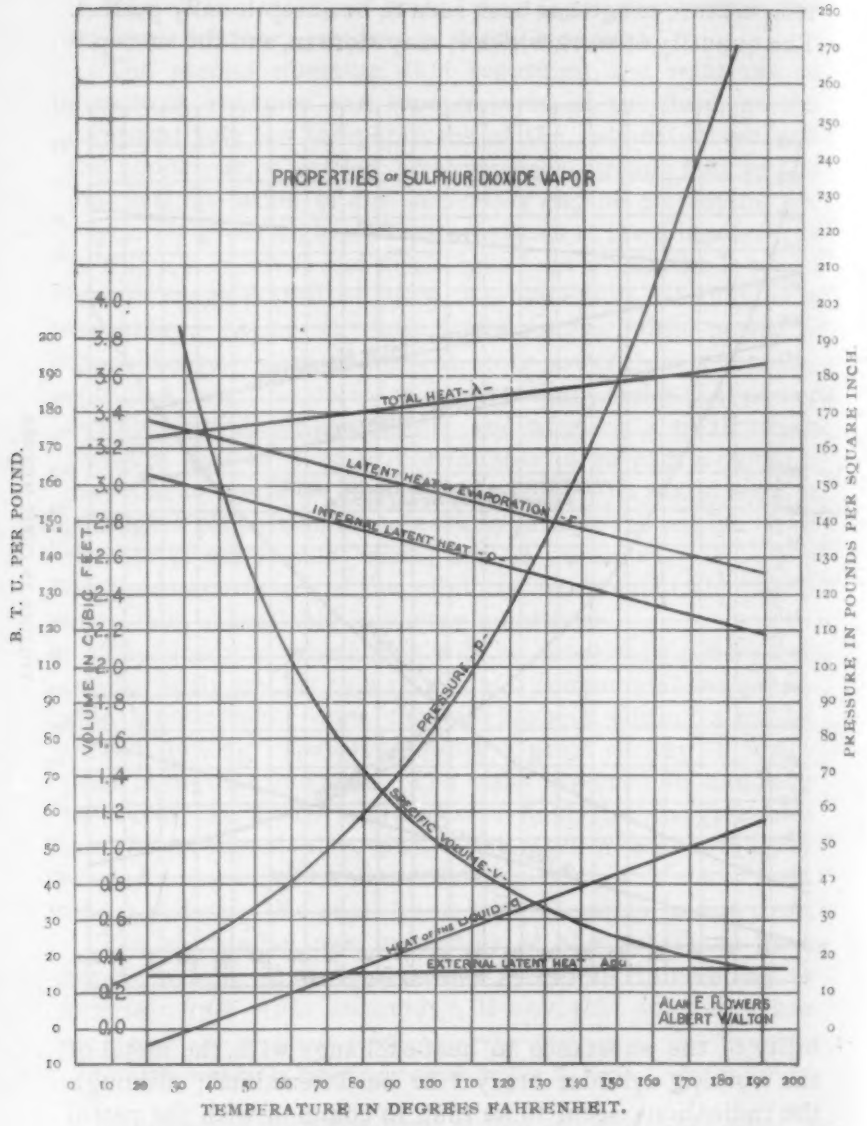
* "Réflexions sur la Puissance motrice du Feu." Paris: Gauthier-Villars, 1878.

"Reflections on the Motive Power of Heat and on Machines Fitted to Develop that Power." By N. L. S. Carnot. Thurston's translation. New York: J. Wiley & Sons, 1890.

over steam and other available working fluids. The adaptation of its pressure-volume relations to the prescribed temperature-range has been seen to be exceptionally perfect. The quantity of work which it may store in, and the suscepti-


PROPERTIES OF SULPHUR DIOXIDE VAPOR
IN UNITS OF THE METRIC SYSTEM
-λ- TOTAL HEAT
-L- LATENT HEAT OF EVAPORATION
-I- INTERNAL LATENT HEAT
-P- PRESSURE
-V- SPECIFIC VOLUME
-q- HEAT OF THE LIQUID
-APV- EXTERNAL LATENT HEAT
PRESSURE IN THOUSAND KILOGRAMS PER SQUARE METER.
COLUMN OF MERCURY IN MILLIMETERS.
VOLUME IN CUBIC METERS.
TEMPERATURE IN DEGREES CENTIGRADE

bility of the substance to heat-exchange with, the metal of the working cylinder are yet to be determined; although the indications seem to be that, in common with the petroleum vapors and some other proposed secondary fluids, it has an advantage over steam in this respect. The oily fluids and


PROPERTIES OF SULPHUR DIOXIDE VAPOR
TOTAL HEAT - λ -
LATENT HEAT OF EVAPORATION - r -
INTERNAL LATENT HEAT - ρ -
PRESSURE - p -
SPECIFIC VOLUME - v -
HEAT OF THE LIQUID - q -
EXTERNAL LATENT HEAT - AQU
ALAN E. FLOWERS
ALBERT WALTON
B. T. U. PER POUND.
VOLUME IN CUBIC FEET.
PRESSURE IN POUNDS PER SQUARE INCH.
TEMPERATURE IN DEGREES FAHRENHEIT.

the gases do not readily transfer heat by conduction; while steam, on the contrary, possesses a remarkable power of discharge of its heat into a cooler metal and of regaining it when the temperature relations are reversed.

A study of the ideal cycle for this case will give interesting facts and will permit later comparison of the behavior of the real engine with its ideal. In this comparison, the main differences may be expected to prove to be due to the differences in readiness of heat-exchange, the ideal case being entirely free from this sort of waste.

A preliminary study of the tabulated physical properties of the substance should preface this investigation. It will be found that the published tables are usually incomplete and sometimes contain errors which must be carefully checked out. The tables are usually very narrow in range and very limited in number of points of observation. The original authority is Regnault, and it is necessary to go back to his paper in the "Memoirs of the French Academy," Vol. XXVI, for the original experimental data. Later writers have proposed various formulas connecting pressures and temperatures, and, among these, perhaps the best is that of Ledoux.* The work of rectification of data and of smoothing up the tables was undertaken, at the suggestion of the writer, by Messrs. A. E. Flowers and Albert Walton. The tables obtained, reduced to both metric and British measures, are herewith presented. The results of computation of the limited number of points determined were laid down, and the smooth curve thus obtained permitted the detection of errors of computation and a complete rectification of the tables. The originals of the curves for both British and metric measures are preserved in the collections of Sibley College.†

All the values are based on Regnault's experiments; but the formulas used were those proposed by later writers. The quantities were computed at temperatures between 0° C. and 80° C. (32° F. and 176° F.). The values for the

* "Annales des Mines," 1878.

† *Sibley Journal of Mechanical Engineering*, June, 1902.

higher temperatures are presumably not absolutely correct, as they were computed by means of formulas based on experiments at lower temperature ranges; but they are the best that could be obtained.

FORMULAS AND METHODS OF COMPUTATION.

Pressure.—Ledoux gives, in the "Annales des Mines," 1878, the following formula for the boiling pressure at different temperatures:

$$p = a\, \alpha^{\frac{t}{1+mt}}$$

in which

p = Pressure in kilograms per square meter.
t = Temperature in degrees centigrade.
a = 15,840, a constant; $\log a = 4{\cdot}199755$.
α = 1·04154, a constant; $\log \alpha = {\cdot}017673$.
m = ·0043129, a constant; $\log a = 8{\cdot}247318 - 10$.

In the original article by Ledoux the value for α is given as 1·04135. The above value for α was computed from the value given by Regnault for the pressure at 35° C.

The following formulas are from Peabody's tables as adapted from Ledoux:

Heat of the liquid, $q = {\cdot}36333\, t + {\cdot}00004\, t^2$.

Total heat, $\lambda = 91{\cdot}396 + 0{\cdot}12723\, t - {\cdot}000131\, t^2$.

Latent heat of evaporation, $L = 91{\cdot}396 - {\cdot}2361\, t - {\cdot}000135\, t^2$.

External latent heat, $Apu = 8{\cdot}243 + {\cdot}196\, t - {\cdot}000116\, t^2$.

Internal latent heat, $\rho = L - Apu$.

Specific volume,

$$v = \frac{BT - Cp^n}{p};$$

where

$B = 13{\cdot}882$
$C = 3{\cdot}8455$
$n = 0{\cdot}4487$

By means of these formulas the quantities were computed for the desired range. These were then converted from the metric to the British system of units, and, for ease in interpolation, plotted on a large sheet of co-ordinate paper, using for common abscissas degrees of temperature.

SYMBOLS EMPLOYED IN TABLE I (METRIC UNITS).

t = Temperature in degrees centigrade.
p = Pressure in kilograms per square meter at which evaporation takes place.
q = Heat of liquid in calories per kilogram.
λ = Total heat of evaporation above o° C. in calories per kilogram.
L = Latent heat of evaporation in calories per kilogram.
ρ = Internal latent heat in calories per kilogram.
Apu = External latent heat of evaporation in calories per kilogram.
S = Specific volume of the saturated vapor in cubic meters per kilogram.

SYMBOLS EMPLOYED IN TABLE II (BRITISH UNITS).

t = Temperature in degrees Fahrenheit.
p = Pressure of dry and saturated vapor boiling at the given temperature.
q = Heat of the liquid in B.T.U. per pound.
λ = Total heat of evaporation in B.T.U. per pound.
L = Latent heat of evaporation in B.T.U. per pound.
ρ = Internal latent heat of evaporation in B.T.U. per pound.
S = Specific volume of vapor in cubic feet per pound.

SATURATED VAPOR OF SULPHUR-DIOXIDE.

TABLE I. METRIC UNITS.

t	p	q	λ	L	ρ	Apu	S
0	15840	0	91·396	91·396	83·153	8·243	·22583
5	19331·2	1·817	92·027	90·212	81·870	8·342	·18337
10	23397·9	3·673	92·655	89·022	80·595	8·427	·15345
15	28102·6	5·46	93·27	87·82	79·31	8·51	·1292
20	33508·5	7·28	93·89	86·62	78·03	8·59	·1096
25	39681·2	9·11	94·49	85·41	76·75	8·66	·09348
30	46688·8	10·93	95·09	84·19	75·46	8·73	·08025
35	54601·0	12·77	95·69	82·97	74·19	8·78	·06929
40	63485·4	14·60	96·27	81·73	72·89	8·84	·06015
45	73416·3	16·43	96·85	80·49	71·60	8·89	·05248
50	84462·7	18·27	97·43	79·25	70·32	8·93	·046007
55	96698·9	20·10	98·00	78·00	69·03	8·97	·04052
60	110194·0	21·94	98·56	76·74	67·74	9·00	·03584
65	125024·0	23·79	98·81	75·48	66·45	9·03	·031835
70	141222·0	25·63	99·66	74·21	65·16	9·05	·028387
75	158961·0	27·47	100·20	72·93	63·87	9·06	·025407
80	178210·0	29·32	100·74	71·64	62·57	9·07	·022820

TABLE II. BRITISH UNITS.

t	p	q	λ	L	ρ	Apu	S
32	22·53	0	164·51	164·51	149·67	14 84	3·6173
41	27·49	3·27	165·65	162·38	147·36	15·02	2·9380
50	33·28	6·55	166·78	160·24	145·07	15·17	2·457
59	39·97	9·83	167·88	158·08	142·75	15·32	2·061
68	47·66	13·10	169 00	155·91	140·45	15·46	1·756
77	56·44	16 39	170·08	153·74	138·15	15·59	1·498
86	66·41	19·67	171·16	151·54	135·83	15·71	1·286
95	77·66	22·98	172·24	149·35	133·54	15·80	1·120
104	90·30	26·28	173·29	147·11	131·20	15·91	·964
113	104·42	29·57	174·33	144·88	128·88	16 00	·841
122	120·13	32·89	175·37	142·65	126·58	16·07	·737
131	137·53	36·18	176·40	140·40	124·25	16·15	·649
140	156·73	39·49	177·40	138·13	121·93	16·20	·574
149	177·82	42·82	178·40	135·86	119·61	16·25	·510
158	200·86	46·13	179·39	133·58	117·29	16·29	·4547
167	226·09	49·45	180·36	131·27	114·97	16·31	·4070
176	253·47	52·78	181·33	128·95	112·62	16·33	·3656

Employing these data, as required, in the comparison of the work of the Berlin secondary engine, from the published accounts of the engine-trials of the machines of which it constitutes an element, we may secure some interesting results. The process adopted by the computers is that usually followed by the writer, adopting the general method of Rankine, with the supplementing and modernization of that system by the introduction, in the real case, of those wastes which do not appear in the purely thermodynamic case. In the present example the question of most interest is that of quantity of extra-thermodynamic waste where the volatile secondary fluid is employed. The data for the real case have been published and are accessible and undoubtedly are entirely accurate.*

The heat reaching the secondary element is that which enters the primary, less the loss, *en route*, by conduction and radiation. The cylinder-condensation waste, it is to be remembered, is not lost as a supply to the succeeding cylinder in any case. All that is absorbed by the metal at entrance

* Berlin Royal Technical High School; Report No. 11, 1899. In English, German and French. Also "Series Vapor and Heat-Waste Engines" R. H. T., *Jour. Frank. Inst.*, October–December, 1902.

of the steam is rejected with the exhaust. It is only the external waste by conduction and radiation and the transformed energy which leaves the system absolutely. Even the friction of the piston in the cylinder reproduces heat, by reconversion of mechanical work into heat, for use by the succeeding element. The heat reaching the larger cylinders of the primary and of the secondary is thus very nearly the full amount entering the high-pressure cylinder of the primary element of the binary engine, less only the equivalent of work performed.

In the tabulated results of Professor Josse's experiments are given the temperatures and pressures of entering and exhaust steam and of entering and exhaust sulphur-dioxide. The limits for the ideal cycles computed were taken as the sulphur-dioxide pressures given for the tests recorded as Nos. 4, 7, 8 and 12.* The initial pressure, p_1, is taken as the absolute pressure at the vaporizer, while the final pressure, p_2, is the absolute pressure of the condenser. In this, the atmospheric pressure is assumed to be the average value of 14·5 pounds per square inch. From these pressures the corresponding values required for computation were found on the curves, as tabulated on the accompanying data sheet.

The heat actually supplied to the SO_2 engine was taken as the total available heat of the superheated entering steam, less the heat-equivalent of the indicated work in the steam-engine, and with a certain allowance for external radiation and conduction losses. The allowance for these losses was about 3 per cent. of the total amount of heat entering the steam-engine. The loss was assumed to be slightly greater for the one case where the steam was nearly saturated, 80,000 B.T.U. per hour being allowed, and 70,000 B.T.U. per hour in the other cases.

The amount of the thermal waste was taken as the difference between the heat-input so calculated and the heat required for an *ideal* SO_2 engine of equal power working through the same range. The amount of this waste, divided by the range of temperature worked through, and by the

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* *Jour. Frank. Inst.*, December, 1902.

area of the internal surface of the SO_2 cylinder, gave the heat-waste in B.T.U. per square foot per degree difference of temperature per hour. This quantity was divided by 60 to reduce it to the heat-waste per minute. The figure thus found for the heat-waste is about that observed for simple condensing steam-engines.

DETERMINATION OF AMOUNT OF HEAT ENTERING SO_2 ENGINE.*

	I.	II.	III.	IV.
Temperature of boiler steam	189·5	302·0	330·0	301·0
Temperature Fahrenheit	373·1	575·6	626·0	573·8
Pressure, lbs per sq. in. gage	156·5	156·5	156·5	158·0
Pressure, lbs., absolute	171·0	171·0	171·0	172·5
Corresponding temperature	368·6	368·6	368·6	369·3
Total heat above 32° of dry saturated steam B.T.U. per lb.	1194·4	1194·4	1194·4	1194·6
Superheat, degrees	4·5	207	257·4	204·5
B.T.U. per lb. due to superheat, 0·4805 x D	2·16	99·5	123·7	98·3
Total heat of steam above 32° in B.T.U. per lb.	1196·6	1293·9	1318·1	1292·9
Per cent. of vacuum	68·2	79·5	75·2	68·5
Absolute pressure of vacuum	4·61	2·975	3·598	4·57
Heat of liquid of exhaust	127·0	109·6	116·6	126·6
Available heat in steam in B.T.U. per pound	1069·7	1184·6	1201·5	1166·3
Total weight of steam per hour	2562	1980	1197	2142
Available heat in steam in B.T.U. per hour	2740571	2345508	1438195	2383197
Horse-power of steam-engine	156·3	145·3	82·4	163·2
B.T.U. equivalent of I.H.P.	397783	369788	209708	415344
Assumed loss by radiation and conduction	80000	70000	70000	70000
B.T.U. per hour available for SO_2 engine	2262788	1905720	1158487	2012871
Horse-power of SO_2 engine	66	50·1	30·6	54·7
Heat required for ideal engine of same range and H.P.	1375440	1189073	635195	1048052
Heat-waste in B.T.U. per hour	887348	716647	523292	964819
Temperature range	82·35	69·40	81·70	90·83
Internal area of SO_2 cylinder in sq. ft.	5·692			
Heat-waste in B.T.U. per degree per square foot per hour	1893	1814	1125	1644
Heat-waste in B.T.U. per degree per square foot per minute	31·55	30·23	18·75	27·39

* See Manual of the Steam-Engine, Thurston. Vol. I, p. 995, *et seq.*

SYMBOLS, TABLE III.*

p_1 = Absolute initial pressure = gage pressure in vaporizer + 14·5 pounds per square inch, atmospheric pressure.

T_1 = Absolute temperature in Fahrenheit degrees = 461° + temperature of ebullition, from curve.

v_1 = Initial volume of SO_2 vapor, from curve.

p_2 = Absolute final pressure in SO_2 condenser, 14·5 pounds per square inch, the assumed pressure of the atmosphere.

T_2 = Absolute final temperature in Fahrenheit degrees, temperature of ebullition corresponding to p_2, from curve.

v_2 = The final volume of SO_2 vapor, from curve.

r = Ratio of expansion = $V_2 \div V_1$.

λ = Total heat of entering SO_2 vapor, from curve.

q_2 = Heat of the liquid of exhaust, from curve.

L = Latent heat of evaporation, from curve.

H_1 = Energy per pound in foot-pounds of entering SO_2 = $J(\lambda - q_2)$.

H' = Energy per pound in foot-pounds of the latent heat of evaporation = JL.

U = Useful energy per pound of SO_2 vapor in foot-pounds

$$= Jc'\left(T_1 - T_2(1 + \log_e \frac{T_1}{T_2})\right) + \frac{T_1 - T_2}{T_1} H'.$$

E = Efficiency

$$= \frac{U}{H}.$$

$M.E.P.'$ = Mean effective pressure in pounds per square foot

$$= \frac{U}{v_2}.$$

$M.E.P.''$ = Mean effective pressure in pounds per square inch

$$= \frac{M.E.P.'}{144}.$$

* *Ibidem.*

A = B.T.U. per I.H.P. hour

$$= \frac{2545}{E}.$$

B = Pounds of SO_2 per I.H.P. hour for efficiency unity

$$= \frac{1980000}{H_1}$$

C = Pounds of SO_2 per I.H.P. hour for actual efficiency

$$= \frac{B}{E}.$$

D = Piston displacement per I.H.P. hour = Cv_2.

D' = Piston displacement per I.H.P.

$$= \frac{D}{60}.$$

F = Pounds of exhaust steam per I.H.P. hour = A divided by the latent heat of the exhaust steam.

J = Mechanical equivalent of heat = 778 foot-pounds.

c' = Specific heat of SO_2 liquid found from curve between temperature limits of 50° and 158° F. = 0·3665.

The formula for U, as given, is based on the assumption that the expansion is complete, and that the final pressure is equal to the back pressure.

SULPHUR-DIOXIDE CYCLES.

	I.	II.	III.	IV.
T_1	616·5	600·95	610·6	621·0
p_1	194·5	156·7	179 4	206·5
v_1	0·468	0·574	0·506	0·443
T_2	534·15	531·55	528·9	530·17
p_2	52·5	50·0	47·6	48·7
v_2	1·602	1·678	1·760	1·720
r	3·425	3·923	3·478	3·882
λ_1	179·05	177·35	178·40	179·50
q_2	15·0	14·05	13·10	13·6
L	134·2	138·25	135·7	133·1
H_1	127630	127047	128603	129070
H'	104400	107558	105574	103552
U	15587	13623	15765	17144
E	·12212	·10723	·12260	·13283

M.E.P.'	9729·7	8118·7	8957·4	9967·4
M.E.P.''	67·56	56·37	62·20	69·21
A	20840	23734	20758	19160
B	15·514	15·58	15·40	15·34
C	127·04	145·29	125·60	115·49
D	205·82	243·80	221·06	198·64
D'	3·43	4·063	3·68	3·31
F	20·182	23·367	20·554	19·061

The expenditure of heat in the secondary cycle, *A*, thus averages, for the ideal case, about 20,000 B.T.U. per I.H.P. hour, not a remarkably low figure; but on the other hand, it costs nothing, as it is supplied by the waste of the primary element of the combination. The quantity of SO_2 per I.H.P. hour for unity efficiency, *B*, under the conditions of its employment in this case, is a trifle above 600 pounds; but this amount is unimportant, commercially, as this is a circulatory system, and once the charge is received into the system, it costs nothing except for renewal or leakage. The quantity demanded for the actual efficiency, *C*, is about 130 pounds and the same remark here applies. The piston displacement per I.H.P. hour, *D*, is about 220 cubic feet, and this will vary with the mean effective pressure on the piston. The same figure, reduced to expenditure per minute, becomes about 3·66. The weight of steam entering the secondary element, per I.H.P. hour, *F*, averages a little more than 20 pounds.

Comparing these figures with those of the trials, as observed and reported as the actual consumption of heat and steam in the secondary engine, it is found that about one-half of the supply to that element is wasted by extra-thermodynamic methods of rejection. How much of this is leakage and how much is thermal waste cannot be determined from the data. It does not appear, however, from this examination of the case that the wastes are less than in the steam-engine in similar cycles. It is, however, sufficiently evident that the main source of the gain observed, when the secondary element with its volatile working fluid is introduced, is to be found in the fact that the result is the securing of high absolute pressures and of large mean effective pressures, with relatively small variation of volumes, at a

part of the thermal range at which steam does not give us pressures of sufficient magnitude to permit the maintenance of satisfactory mechanical efficiency of the engine or to produce commercially satisfactory sizes and weights of the motor.*

MINUTE MECHANISM.

Modern Machinery contains some interesting facts about the minuteness of some of the screws made in an American watch factory. It takes nearly 130,000 of a certain kind to weigh a pound. Under a microscope, they appear in their true character—perfectly finished bolts. The pivot of the balance wheel is only $\frac{1}{200}$ of an inch in diameter, and the gage with which pivots are classified measures to the $\frac{1}{10000}$ part of an inch. Each jewel hole in which a pivot fits is about $\frac{1}{5000}$ of an inch larger than the pivot to permit sufficient play. The finest screw for a small-sized watch has a thread of 260 to the inch, and weighs $\frac{1}{130000}$ of a pound. Jewel slabs of sapphire, ruby or garnet are first sawed into slabs $\frac{1}{50}$ of an inch thick and are shellacked to plates so that they may be surfaced. Then the individual jewels are sawed or broken off, drilled through the center, and a depression made in the convex side for an oil cup. A pallet jewel weighs $\frac{1}{120000}$ of a pound; a roller jewel a little more than $\frac{1}{125000}$. The largest round hairspring stud is $\frac{1}{100}$ of an inch in diameter and about $\frac{9}{100}$ of an inch in length.

ALUMINUM ALLOYS.

Aluminum World is authority for the statement that an alloy consisting of 18·87 per cent. of aluminum and 81·13 per cent. of antimony is a marked exception to the general rule that alloys are more fusible than the least fusible metal contained. Aluminum and antimony melt at nearly the same point, which is in the neighborhood of 1,160° F.; this alloy does not melt until a temperature of 1,976° F. is reached. Most alloys are denser than their constitutents; this alloy is less dense. Quantitatively, 7·07 cubic inches of aluminum, alloyed with 12·07 of antimony, produces 23·71 cubic inches of alloy, thus showing an increase in volume of 4·55 cubic inches, or 24 per cent.

The *Iron Age* gives us the following item:

A French engineer is alleged to have discovered alloys for aluminum which impart to this metal most extraordinary qualities. By varying the amount of his alloy from 1 part in 12 to 1 part in 240 he obtains compounds varying in tensile strength from 29,000 to 58,000 pounds per square inch. These are so different in characteristics that they may be chased, soldered, brazed, forged, rolled into plates and leaves, or drawn into wire, all depending on the amount of the alloy. It can be made soft, like pure aluminum, or stiff and rigid like steel, and possessed of nearly the same strength, on one-third the weight.

* For details of methods of treatment and of computation, see Manual of the Steam-Engine, Vol. I, §§ 137, 149, 155, and notes, pp. 995–1004. R. H. T.

ELECTRICAL SECTION.

Stated Meeting, held Thursday, February 12, 1903.

Notes on Recent Electrical and Scientific Developments Abroad.

By William J. Hammer,
Consulting Electrical Engineer, New York.

(*Concluded from p. 340.*)

RADIUM, POLONIUM AND ACTINIUM.

I have brought with me to-night a collection of tubes containing phosphorescent substances which I have been gathering abroad and in this country. These substances which I will show you become phosphorescent when exposed to some source of vibration, such as light, heat and electricity. Practically, all substances in nature are phosphorescent to a greater or less extent.

Certain of these phosphoresce for only one-ten-thousandth of a second, while others for many hours.

A substance, such as sulphide of calcium, which I have here in this bottle, may be exposed to sunlight, and after being put away for six weeks in the dark will still affect a photograph plate.

By burning this piece of magnesium wire before these tubes, you will notice that they become brilliantly phosphorescent, and show a large variety of shades of colors.

I now wish to call your attention to those most remarkable substances which are probably attracting more attention in the scientific world than any substances which have ever been discovered. These are radium, polonium and actinium.

I have brought with me to-night some nine different preparations of radium, the most powerful of which has a radioactivity of 7,000, and also two tubes containing a preparation of polonium and bismuth in the metallic and subnitrate forms.

In the discovery of these remarkable properties we must

go back first to the experiments of M. Henry and M. Niewenglowsky. The former showed that phosphorescent sulphide of zinc penetrated black paper and affected a photograph plate similar to Roentgen rays; and the latter placed a photograph plate in a plate-holder, covering the same with a sheet of aluminum, on which he placed a number of square pieces of glass. On this glass he sprinkled sulphide of calcium, which had been exposed to sunlight; and after covering over each of the glasses with a watchmaker's glass, resembling a goblet with the stem cut off, he put the plate away for a period of twenty-three hours; after which, on developing the same, he found that the squares of glass and the rim of the goblets were plainly photographed on the plate.

The rays which penetrated the aluminum were ordinary light-waves, which were shown by the refraction of the light where it had passed through the rim of the glass covers.

Becquerel, at about this period (1896) was experimenting with various phosphorescent substances, and exposed some salts of uranium (double sulphate of uranium and potassium) to sunlight to make them phosphoresce, and was then trying their effect on a photograph plate. During a period of inclement weather he put the plate away in a drawer, and after several days he took the plate out and developed it, when, much to his surprise, he secured a better image than he had made before by exposure to sunlight. This led to his discovering and investigating the properties of what have ever since been called "Becquerel" rays.

This was in 1896, and subsequently in 1898, Prof. P. Curie and his wife, Mme. Sklodowska Curie, in studying these Becquerel radiations, found some samples of pitchblende, from which the uranium is extracted, which was much more powerful than any uranium they had ever found; and this convinced them that there must be some substance in uranium which produced Becquerel rays. After much painstaking investigation they succeeded in discovering a new element which Mme. Curie named Polonium, after Poland, her native country.

Polonium, in its chemical and other characteristics, bears a marked resemblance to barium, with which it is associated.

During the same year M. and Mme. Curie and M. Bemont succeeded in isolating a new substance which they called "radium," which possesses the same chemical and other characteristics of barium with which it is associated.

In 1899, M. Debierne discovered a new preparation which possessed the chemical and other characteristics of thorium, which he named "actinium."

These three substances, all of them being produced from the uranium residues, are spoken of as new elements, although in the case of polonium and actinium they have as yet not been prepared of sufficient quality and quantity to absolutely demonstrate that they are new elements. In the case of radium, however, this has been demonstrated beyond peradventure.

During my visit in Paris last September I had the pleasure of visiting Professor Curie at his laboratory and seeing some very interesting experiments; and among other things he showed me a tiny tube containing between $\frac{2}{100}$ and $\frac{3}{100}$ of a gram of radium. This he held up to the light and stated that it represented the only samples of chemically pure radium in the world. I asked how he had demonstrated it to be chemically pure, and he said that this was the sample with which M. Demarcay had made his investigations with the spectroscope, and had shown that there were only present the lines characteristic of radium, and this was the identical sample with which the atomic weight had been determined to be 225, while that of barium, with which it is associated, is but 157.

I asked Professor Curie what was the value of this tiny tube, which is about the size of a buck-shot, and he said that the value was anything which one might place upon it; and on my asking whether $20,000 would buy it he said, no, indeed; but he showed me a tiny tube which contained perhaps $\frac{3}{100}$ of a gram which still contained a considerable trace of barium, which he was willing to dispose of for the sum of $5,000.

Up to the present time the laboratory at which the radium is prepared, and which is under the control of Professor Curie, has not permitted any radium to be sent out with a radioactivity over 7,000, the better grades being retained for investigations going on at the laboratory.

I have within a few days, however, received a letter from the laboratory stating that very shortly radium would be placed upon the market at a cost of 30,000 francs or $6,000 per gram ($2,721,555.90 per pound).

Radium is by far the most interesting of the three new substances which have been discovered, and its remarkable properties have very much unsettled the minds of the scientific world; and none of the theories which have up to the present been advanced satisfactorily account for all the phenomena due to radium.

My friend, Mr. R. R. Bowker, whom I met in Paris last fall, told me that he had shortly before that been dining with Lord Kelvin seated on one side and Professor Becquerel on the other, and Lord Kelvin had turned to him and stated that the discovery of Becquerel radiations had placed the first question-mark against the principle of conservation of energy which had ever been placed against it since that principle was enunciated.

I will now endeavor to tell you of a few of the remarkable properties which these new elements possess. First, however, I will pass around the room, and if the lights are put out, show you some half dozen or more tubes of radium, which you will note are brilliantly phosphorescent in the dark.

Now, in contradistinction to the substances which I showed you, and which I excited by burning the magnesium wire, these tubes of radium give off this powerful light without having to be excited by any vibrations of any character, so far as we know.

Preparations of radium have been made in a dark room and have been kept there for a period of two years, and during that time have not lost their luminosity in the slightest degree.

One might almost consider that this substance is matter

tearing itself into pieces and projecting these pieces with from half to the full speed of light, for the particles are evidently carried through all matter. The very walls of this room and the clothes of those who are present are at this moment all radioactive, due to the presence of radium in the room. This and other phenomena of radium cause one to naturally "hark back" to the Newtonian corpuscular theory of light.

Professor Curie told me that he was frequently forced to delay his tests for a period of three or four hours by reason of the fact that he had been exposed to some radium, and his clothes had become so radioactive as to prevent his going near his instruments.

By wrapping a little cotton around one of these tubes and holding it in the dark you will find that the entire mass is brilliantly phosphorescent. This is not due to the mere light passing through the cotton, but to the fact that the cotton itself has become radioactive.

Elster and Geitel have shown that if a wire is placed in the atmosphere and charged negatively from a source of current, say 500 volts, the wire itself becomes radioactive, and this radioactivity can be scraped off, and will affect photograph plates, ionize the air, etc.

McLennan has made experiments on this line in Montreal, and subsequently negatively charged a wire placed at the foot of Niagara Falls from the electricity present in the atmosphere, and produced a result about $\frac{1}{6}$ as powerful as that produced in Montreal.

It is well known that falling rain and snow are for a time quite powerfully radioactive, and after a snowstorm the wire negatively electrified in the atmosphere has only a small amount of radioactivity, showing that the snow has probably carried the radioactive particles in the atmosphere down with it to the ground.

Professor Rutherford, of Montreal, one of the ablest investigators of radioactivity, has given a great deal of attention to thorium, which is the most radioactive substance next to radium which has been discovered. He electrified a wire negatively by connecting one side of a battery of 500

volts to the wire, and grounding the other side of the battery; and by connecting the sample of thorium to the ground he attracted the thorium particles to the negatively charged wire and produced a greater radioactivity than he has ever found in any thorium preparation which he has made.

Radium has three entirely distinct classes of rays.

The "α"-rays, which constitute by far the most important class of these and the largest quantity, are those which produce the greater portion of the ionization of the air observed under experimental conditions.

These rays have in common certain of the characteristics of X-rays, and by many have been thought to be X-rays.

Rutherford has, however, recently shown that these rays in a powerful field are slightly deflectable. Originally they had been considered absolutely non-deviable, as are X-rays.

These "α"-rays are readily absorbed, and a thin screen of any metal will serve to cut off the greater portion of them.

The "β"-rays are much longer and much more penetrative, and in every respect possess the qualities of cathode rays. They are readily deflected by a magnet, discharge electrified bodies by ionization of the air, and affect photograph plates, etc.

Crookes and Strutt suggested that the "α"-rays consist of positively electrified bodies, and Rutherford supports this, stating that they have characteristics similar to Goldstein's Canal Strahlen, which have been shown by Wien to be positively charged bodies moving at high velocity; although Rutherford considers that the particles from the "α"-rays move at much higher velocity than the Goldstein rays. Rutherford estimates that the energy of "α"-rays is a thousand times greater than that of "β"-rays; and some experiments made by him show that the relative penetration of the three classes of rays in passing through a certain thickness of aluminum before half of the intensity is reduced is as follows:

	Thickness of Aluminum
"α"	·0005 cm.
"β"	·05 cm.
"γ"	8· cm.

The X-rays are the rays with the greatest penetrative quality, and may produce an effect in the air even a meter or more distant. These rays are not at all influenced by a magnet.

The Curies have shown that radium dissolved in water and evaporated to dryness very largely loses its power of emitting "β"-rays,and it appears that the emission of "α"-rays goes on entirely independent of the "β"-rays; and it is now considered that the "β"-rays are a secondary phenomena, the "α"-rays playing by far the principal part in changes which occur.

The rays from radium produce many interesting chemical effects.

I hold in my hand here a large glass bottle, which I secured at the Paris laboratory, which contained radium, which has been powerfully affected by radium rays changing it to a deep violet color, which will always remain.

I also hold in my hand a tiny tube in which the chemical constituents of the glass have been such that when the radium acted upon them the glass was changed to a dark brown. This tiny tube is a duplicate of the very interesting tube which Professor Curie showed me, which contained between two and three grams of chemically pure radium.

Glass, porcelain, paper and other substances are changed in color by the action of radium.

Platino barium cyanide is changed from a greenish-yellow to a brown variety when it polarizes light, like the tourmaline crystal.

White phosphorus is changed to red phosphorus in about twenty-four hours.

None of the rays from radium can be refracted, reflected or polarized, showing that they are not light waves.

Prof. J. J. Thomson, in his address before the British Association last summer, repeating statements of Professor Becquerel, stated that if a square centimeter of surface were covered with pure radium it would only lose in weight ·001 milligram of the substance in a million years.

Recently, however, Heydweiller, of Germany, has stated that a preparation of de Haen's radium, which he had

tested, lost ·02 milligram per day, and that in fifty days an entire milligram in weight had been lost.

I wrote to Professor Thomson asking him to account for the discrepancy in the two statements, and he wrote me that while he was not entirely familiar with Heydweiller's experiments, and was not quite certain of the cause of the loss claimed, he called attention to the effect which radium produces of coloring glass in which it is placed a deep violet color, and he stated that if this coloring went entirely through the glass, as he was led to suppose, there was perhaps a reaction when the rays appeared on the outside of the glass which caused destruction of the glass itself and lessening in the weight of the glass envelope, and not of the radium itself.

The original statement made by Professor Thomson was based on the statement of Professor Becquerel; and Becquerel's statement was based upon the investigations which he had made on the deflectable or β-rays.

With the tremendous velocity with which the particles are projected through all matter, one would be led to suppose that there must be some loss in weight where all the phenomena of the radiation are taken into consideration; but there are those who believe there is an equilibrium process going on with radium, so that the actual loss is infinitesimal.

J. J. Thomson and Rutherford advance the theory that there is a succession of chemical changes going on, causing the spontaneous projection of larger masses of material at enormous velocities, and that while certain portions are constantly dying out and becoming inert, other portions are constantly increasing in strength and power.

Mme. Curie had advanced the theory that there may be present in the ether certain vibrations with which we have not been cognizant, with which radium vibrates in harmony the moment it is created.

Radium produces most powerful physiological effects.

Professor Curie showed me a scar on his arm which had been caused by a serious ulcer produced by some radium which he had placed in a small capsule, and put it on the

outside of his coat sleeve for a period of about an hour and a half. The back of his hand was also badly burned and the skin all peeled off, due to the small sample of radium of very high radioactivity which he had placed on the back of his hand for a period of about five minutes.

Those who have worked with radium have noted that the finger-tips become exceedingly sensitive in handling radium, and the writer recently experienced considerable soreness for over a month, due to carrying a wooden box with a number of tubes of radium under his arm for several hours, while attending the American Association meeting at Washington during the Christmas holidays. The radium was in sealed glass tubes, and the tubes placed in glass bottles laid in cotton inside of the wooden box. The manifestations of burning from radium, which are very similar to X-ray burns, do not display themselves for a period of about two weeks after exposure. Quite a number of instances are recorded of the serious character of the radium burns, and in talking with Professor Curie I asked him whether he had ever seen a kilo of radium, and whether a kilo of radium had ever been produced, and he said no; that in the last three years, with all the work that had been done in Germany and France, only between 500 and 600 grammes of radium had been produced, *i. e.*, in the neighborhood of a pound. He stated, furthermore, that he would not care to trust himself in a room with a kilo of radium; and on my asking him why, he said because it would destroy his eyesight, burn all of the skin off his body, and probably kill him.

There are great possibilities in the use of radium for the treatment of certain classes of disease. Aschkinass and Caspari have exposed some cultures of micrococcus prodigiosus to radium, and in three hours they have all been killed.

Some promising results have also been claimed by Dr. Oudin from its use in the treatment of lupus. There are also possibilities in the treatment of neuralgia and the diagnosing of paralysis of the optic nerve. If a tube containing radium is held to the closed eye or against the temples, a powerful impression of light is produced. This is

due probably to the action of the radium on the phosphorescence in the pupil of the eye, and possibly also to its action on the nerve centers.

If a pile of seeds is divided into two parts and one portion is exposed to radium for a considerable period, and then both piles are planted, it is found that the seeds exposed to radium have lost their germinating properties.

Professor Curie informed me that radium emits exactly the same quantity of Becquerel rays when exposed to liquid air as it does at the normal temperature of the atmosphere; that the luminosity of the chloride of radium is stronger in the liquid air than in the atmosphere at normal temperature; but that the strength of the radiation is not altered.

If a gold-leaf electroscope is charged negatively by a rubbed ebonite rod, and the leaves caused to diverge, one can, by bringing some radium near the electroscope, cause the leaves to come together, showing that the air has been ionized, or made a conductor of electricity, and thus dissipating the charge in the gold-leaf.

If some radium is put in a lead vessel, beneath two plates of a condenser, one side of the condenser being attached to a source of current, say 500 volts, and the other side of the battery being grounded; and if the other plate of the condenser be connected to an electrometer, the radium rays will pass up between the plates of the condenser, making the air a conductor of electricity, so that the current will pass across from one plate to the other and measurements may be made by means of the electrometer.

In addition to the chemical effects already referred to, radium rays will reduce silver salts, bichromate of potash and peroxide of iron in the presence of organic substances. They will also reduce chlorine in the presence of oxalic acid with a precipitation of calomel. Oxygen is also changed into ozone.

The little bottle of sulphide of calcium which I showed you and which I exposed to the light, was not phosphorescent all the way through the mass, but in the case of radium the light is given from the entire mass.

All substances in the neighborhood of radium become radioactive, and this radioactivity which is imparted may produce for a time the same effects as the original substance.

Professor Curie states that one-half of this induced radioactivity, when exposed to the air, is lost in certain substances in half an hour; but in a closed vessel, where the air has been made radioactive, this radioactivity has not lost half of its strength in four days.

Radium is somewhat hygroscopic, and it should therefore be kept free from moisture in sealed tubes. If exposed to moisture it soon loses its luminosity; but this may be recovered by making a solution and precipitating the substance and thoroughly drying it. The luminosity may be very largely increased by subjecting the radium to very high temperatures.

Actinium, which was discovered by M. Debierne, and is similar to thorium, is precipitated by ammonium sulphhydrate. The rays from actinium are deviable.

Polonium, which was the original element discovered and which resembles bismuth, is precipitated by hydrogen sulphide.

I hold in my hand here two small tubes of polonium, in the subnitrate and metallic forms. The latter resembles metallic particles of nickel.

Professor Crookes has shown that the rays from polonium do not penetrate glass; they only extend about 4 centimeters from the original source and are nondeflectable.

Giesel, however, has prepared a form of polonium which possesses both deviable and nondeviable rays.

The Curies have not been able to prepare any which is deviable.

Elster states that when polonium is placed in a vacuum the rays emanating from it deviate to a greater extent than those of radium.

Polonium apparently loses its power much more rapidly than radium.

In the preparation of radium it is necessary to refine some 5,000 tons of uranium residues to produce a little over

2 pounds of radium, and it costs about $2,000 per ton to refine these residues.

More attention in the scientific world has been attracted to the phenomena of these radioactive substances than was attracted by the discovery of Roentgen-rays, or X-rays; and it is doubtful if anything has been discovered since the beginning of the world which has possessed such fascinating interest to scientific men, and which is so fraught with possibilities; and it seems likely to contribute to our knowledge of the constitution of matter to a degree which no other substance heretofore discovered has ever done.

I shall now show you a number of interesting lantern slides of photographs made with phosphorescent substances and radium, which show certain of the X-ray and other characteristics of the radium rays, and also an illustration of the apparatus used by Professor Curie in testing the radioactive properties of radium. In this connection it is interesting to note that electrical analysis with the electroscope and electrometer has proven a million times more sensitive than chemical analysis, and thousands of times more sensitive than spectrum analysis; and that the electroscope will test the radioactivity of a preparation of radium, which it is necessary to produce 5,000 times as powerful in order to have it show in the spectroscope.

FINSEN'S ULTRA-VIOLET RAY TREATMENT OF DISEASE.

During my sojourn in Europe last year business called me to Copenhagen, and while there I had the pleasure of visiting the Finsen Medical Light Institute, established in 1896, and was very much impressed with the beneficent results derived from Finsen's treatment of disease by the ultra-violet light.

I hold in my hand a copy of Gen. A. J. Pleasonton's book, entitled "Blue and Sunlights: Their Influence upon Life and Disease," which I picked up some years ago in a second-hand book-store for the munificent sum of 15 cents, and to those who are interested in the bactericidal effects of light upon disease germs I would commend to them the consideration of this book, which carries one back to the

blue-glass craze of 1876 and thereabouts. Although he was branded a charlatan, and his system made the butt of the funny papers, Finsen says: "The General was absolutely on the right track."

Professor Finsen has conducted some very elaborate and painstaking researches into the treatment of disease by ultra-violet light, and has found both ends of the spectrum to possess remarkable curative powers; and he has employed most successfully the red end of the spectrum in connection with the treatment of small-pox; and has also found it most successful in the removal without pain of such disfigurements as birth-marks, moles, etc. And then, by using the other end of the spectrum containing the blue-violet, and especially the ultra-violet rays, he has very successfully combated that horrible disease, tuberculosis of the skin, or "lupus," a disease which heretofore has baffled surgical skill.

It is interesting to note that in New York City alone there are 20,000 cases of tuberculosis, and 8,000 deaths annually—this disease exceeding, probably, in importance and deadly character, all diseases which flesh is heir to.

When attacking certain of the internal organs it appears as consumption; but on attacking the skin or flesh tissues it produces tuberculosis of the skin and is known as that loathsome disease, "lupus" (wolf). It is said that there are no bacillogenous diseases of the skin of such clinical importance and interest as the varieties of primary and secondary tuberculosis.

The investigations of Koch and others have demonstrated the presence of specific organisms, which have been named tubercle bacillus, present in both the internal and cutaneous forms of the disease.

Lupus appears in a number of forms; but its most important and most common is that of "lupus vulgaris." As a rule, it appears in single patches. The face is the favorite seat of the disease, especially the nose, cheek and mouth. It also frequently attacks the extremities, and may appear anywhere.

When Professor Finsen first began his work little cre-

dence was given to the results which he claimed; but to-day too much cannot be said in his praise, and the results claimed by him have been verified by many others in different parts of the world; and it is interesting to note that recently Professor Finsen has received the award of the Nobel prize of $50,000 for his interesting contribution to medicine and surgery.

In the treatment of small-pox Professor Finsen found that by placing the patients in a room from which ordinary sunlight was excluded, the room being illuminated only by the rays which penetrated through red glass, such as one would use in a photographic dark-room, the red rays had a soothing effect upon the patients and prevented entirely the suppuration, if treated before the suppuration stage, and also the scarring usually resulting; the fever accompanying the eruption disappeared, the temperature remained normal, and the disease was always of a much milder form.

If such patients were subjected to the rays of the blue, violet, and ultra-violet end of the spectrum, the disease would be very much aggravated.

Even parties who have been exposed to red rays in a room have been found to have had the disease very much aggravated by going out in the sunlight before fully cured. This aggravation of the disease is caused by actinic rays, or the most refrangible rays, which produce a sunburning which one often experiences in high altitudes, where the temperature may be considerably below zero, and has often been observed by those who are working close to arc lamps. This excitation or stimulation produced by these rays, while it is very harmful in cases of small-pox, is the very thing that is needed in such diseases as tuberculosis of the skin and lupus vulgaris. Here it is found that the bacilli are killed, nutrition and granulation are stimulated, and the patients are ultimately cured of the disease.

The rays of the sun are undoubtedly very rich in blue, violet and ultra-violet light; but in passing through the atmosphere these rays are very largely absorbed, and they are too slow for the most effective treatment; besides the sun was often obscured; and Professor Finsen in his recent

work has therefore employed a carbon arc light, using from 40 to 80 amperes and 45 to 50 volts, which source of light is much richer in ultra-violet rays; and others, such as Broca and Chatin, in Paris, and Görl, of Erlangen, have used the iron and aluminium arcs, which are still richer in ultra-violet rays, and which, it is claimed, also enables more rapid treatment than in the case of the carbon arc—Broca claiming his iron lamp will do in twenty minutes what Finsen does in his treatment of one hour and ten minutes.

In Professor Finsen's first experiments he employed a glass bottle which was practically a plano-convex lens. This flask was filled with a light-blue ammoniacal solution of sulphate of copper, and subsequently with plain water, and the sun's rays were passed through this solution and focussed upon the patients to be treated.

In the more recent treatment in which the arc-lamp is employed, a telescope containing four rock-crystal lenses is employed, the rays of the arc-lamp being passed through these rock-crystal lenses and also through chambers containing distilled water, these serving to cut off and absorb the heat rays of the spectrum while they allow the ultra-violet rays to penetrate.

A rock crystal 4·4 millimeters thick will allow 60 per cent. of the ultra-violet rays to pass through it, whereas ordinary glass almost entirely cuts these rays off.

Around the portion of the telescope containing the distilled water is a jacket containing circulating water to conduct away the heat.

It is found that blood does not permit ultra-violet rays to pass through it, and it is therefore necessary to drive the blood from the diseased portion of the skin. This is accomplished by a plano-convex lens of rock crystal which is kept cool by circulating water. It is claimed that by the use of the iron arc water cooling is unnecessary, and that pressure to drive blood away is also unnecessary.

When the glass is pressed on the diseased part the pressure drives the blood away from that portion and allows the rays to penetrate. At the Finsen Institute it is usual to expose the patient to a treatment of an hour and ten minutes,

after which the patient appears as if he had been badly sunburned. He is then allowed to recuperate until the next day, and the treatment is continued over and over again. After a certain number of treatments the patient is generally dismissed as cured; but while in some cases there is no recurrence, in other cases it is found that the microbes which were deep-seated have worked their way to the surface, and it is necessary for a second course of treatment, and sometimes three or more; although in many cases two or three sets of treatment are all that is sufficient to absolutely cure the patient of this loathsome disease. Of over 600 cases treated at Copenhagen it is claimed there have been no failures due to fault in treatment, though some had progressed too far before treatment commenced.

The charge for the treatment only ranges from $18 per month to less than $1 per day.

I have here some photographs and slides, which I secured through the courtesy of the Finsen Institute, which show a number of the patients before and after this treatment. One cannot look at these without feeling impressed with the glorious work which has been accomplished by Professor Finsen, and which is now being taken up all over the civilized world, and which is opening up a new life to many of the most sorely afflicted people of this world of ours.

SELENIUM.

Before closing my lecture I wish to invite your attention to that remarkable substance "selenium."

It was discovered by Berzelius in 1817 as a by-product in the manufacture of sulphuric acid from the distillation of iron pyrites. Its characteristics are similar to sulphur, phosphorus and tellurium. If melted at 212 degrees Centigrade and cooled rapidly it becomes a brown amorphous mass of conchoidal fracture, and in this form is a non-conductor of electricity. If heated to only 100 degrees Centigrade for a considerable period, it becomes a conductor of electricity to a slight extent, this increasing with the increase of current.

Hittorf in 1851 first discovered the effect of temperature on selenium.

On February 12, 1873, Mr. Willoughby-Smith presented a communication to the Society of Telegraph Engineers of London, referring to the effect of light in reducing the resistance of selenium. An assistant of his, Mr. May, a telegraph clerk at Valencia, had noted these phenomena in some selenium resistances used in connection with the cable work, and called the attention of Mr. Willoughby-Smith, who had charge of the submarine cable testing, to them.

At the present time there is a considerable revival of interest in the properties of selenium, and notable advances have been made. Much work has been done in this direction in the past by Messrs. Shelford Bidwell, F.R.S., J. W. Giltay, Lord Ross, Sale, Draper and Moss, W. G. Adams and R. E. Day, Mercadier, Fritts, Ruhmer, Minchin, Bell and others.

Prof. Alexander Graham Bell has made some interesting experiments with his radiophone, in which a silvered diaphragm, which reflected a powerful beam of light, fell upon a selenium cell connected to a telephone and battery. At the back of the silvered diaphragm was a flexible tube or mouthpiece, into which words were spoken. This caused the diaphragm to vibrate, sending pulsations of the reflected light upon the selenium cell, which correspondingly varied its resistance and produced audible sounds in the telephone.

Subsequently, Professor Simon, of Germany, discovered that the light of an arc lamp placed in proximity to a telephone circuit was caused to vibrate perceptibly while the telephone was being operated, and he devised a speaking arc by superimposing the sound waves produced by the telephone upon the circuit in which the arc was placed.

Subsequently this work was taken up by Duddell, of England, and Ernest Ruhmer, of Berlin, the latter particularly following this matter most industriously and producing results of far-reaching importance, and surpassing those which had been attained by others.

I had the pleasure of seeing Mr. Ruhmer's apparatus last summer in Berlin, with which he succeeded in talking over a beam of light 4¼ miles in length, employing for this an arc lamp with a current of from 12 to 16 amperes.

At the Electrical Exhibition held in Madison Square Garden in May, 1899, Mr. Hayes showed an interesting experiment in this line. At one end of the Garden was placed a telephone before which a cornet was played, causing waves of current in the telephone circuit to be superimposed upon those in a neighboring arc light circuit; the light rays from this arc lamp were reflected across the Garden, where they were received in a parabolic reflector, in the focus of which was a glass tube containing carbon filaments. To this tube were connected the ordinary listening tubes, such as used with the Edison phonograph. The varying light falling upon the carbon caused variations of the temperature of the air inside the tube, reproducing perfectly the original sounds in the listener's ear. A bulb coated with lampblack and containing nothing but air may be used.

The slide which I now throw on the screen illustrates the arrangement of the apparatus employed by Mr. Ruhmer, and I take pleasure in presenting also several other important applications of selenium, which are the results of Mr. Ruhmer's painstaking investigations.

I hold here in my hand the latest form of Ruhmer's cell, which you observe resembles somewhat an incandescent lamp. The cell itself is placed inside of a glass globe from which the air is exhausted, and the terminals are attached to a lamp-base similar to that of the Edison incandescent lamp, this forming a most convenient method of mounting these cells.

In making selenium cells it is usual to wind two separate windings of wire (either copper, brass, German silver, or platinum) equidistant throughout their whole length; these windings being placed usually on slate, glass, mica or porcelain, and the selenium being spread evenly over the wires, forming an insulation between the two circuits. The Ruhmer cell which I have shown you employs copper wire wound on porcelain and placed in an exhausted glass bulb, as already described. Mr. Ruhmer also employs platinum wires wound on a cylinder of glass.

Considerable difficulty has been experienced heretofore

in employing selenium cells by reason of their being so susceptible to moisture, and it is this taking up of moisture which produces the electrolytic effect in the cell, which has enabled one to connect the cell with a galvanometer and, by merely focusing the light upon the cell, producing a current in the cell itself. This resulted in the designation of the "photo-electric cell."

Such an effect as this would not be present where the cell is placed inside of a vacuum, and this device of Mr.

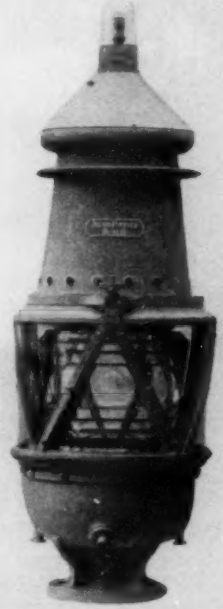


FIG. 11.—Buoy containing Pintsch gas and controlled by Ruhmer's selenium cell.

Ruhmer is a most important step towards the commercial development of it.

In the slide now on the screen (see *Fig. 11*) you will note an interesting application of Mr. Ruhmer's cell to the gas-buoy, such as is employed at sea. These buoys may contain a charge of compressed gas which will last from thirty days to six months and even a year.

It had been necessary up to the present for these buoys to burn both night and day on account of the impossibility of turning the gas off during the daytime. Mr. Ruhmer has placed one of his cells in the top of the buoy and connected it with a relay, a switching device and battery, by means of which when the sun rises in the morning the resist-

FIG. 12.—Ernest Ruhmer's photographophone (exterior view).

ance of the selenium cell is lowered, sending more current through the relay and operating the local circuit containing the switching device and battery which turns the gas off. As soon as night approaches, or in case of storm, the selenium increases its resistance and the opposite effect takes place, the gas being again turned on.

When I was in Berlin last August one of these buoys

had been in operation since the previous October, and Mr. Ruhmer has recently written me that it is still operating successfully, as are others which have been placed near Hamburg and in the Baltic Sea.

Mr. Ruhmer has built a piece of apparatus which he has called the "photographophone," which I consider one of the

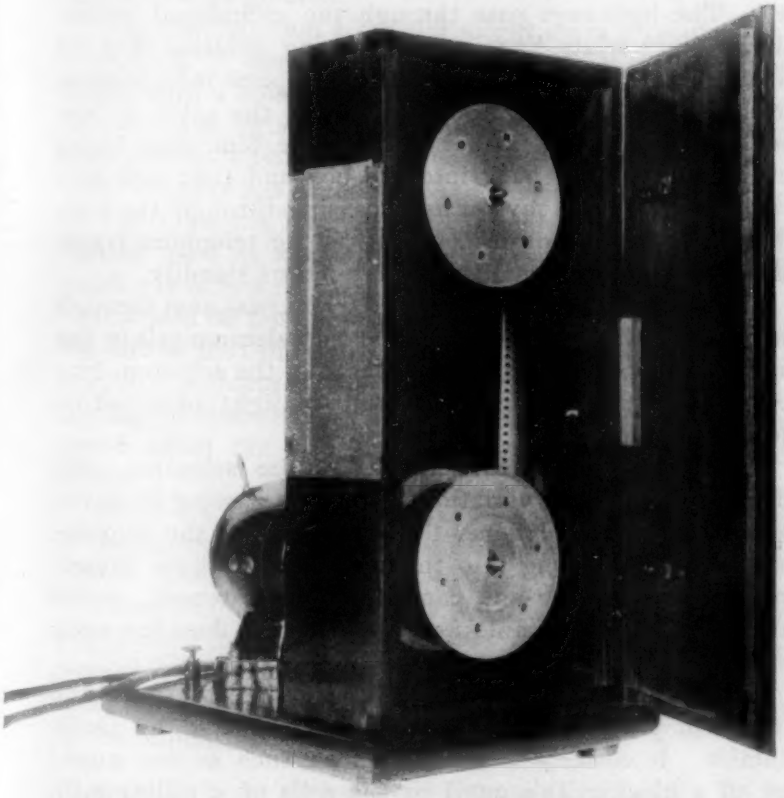


FIG. 13.—Ernest Ruhmer's photographophone (interior view).

most remarkable inventions which I have ever seen. The illustration of this is shown in *Figs. 12* and *13*.

I shall now throw on the screen a number of slides illustrating the construction and operation of this apparatus. It consists of a box containing a gelatine film, such as used in moving-picture machines. Back of the film he has placed

a selenium cell which is connected to a battery and telephones. These telephones may be at any distant point. In the front of the box is a cylindrical lens, and placed in front of the lens is an arc lamp and a telephone. When words are spoken or sung into the telephone the waves started up in the telephone circuit are superimposed on the circuit embracing the arc lamp, causing the light to vary in intensity. The light-rays pass through the cylindrical prism, fall in sharp white lines on the moving gelatine film on which they are photographed. When the pitch is high these striations are close together, and when the pitch is low they are broader and farther apart. The film after being developed is placed back into the box and then acts as a screen to cut off the rays of light passing through the lens. These rays are now quite constant, as the telephone transmitter has been removed and the arc burns steadily.

The rays after passing through the lens pass next through the gelatine film, and impinge upon the selenium cell in the back of the box, varying the resistance of the selenium in a degree corresponding to the amount of light admitted by the moving film.

The variation in the resistance of the selenium cells affects corresponding variations in current passing from the battery into the telephone, thus reproducing the original sounds spoken or sung into the telephone. I have myself operated this device and can verify the statement of the inventor, that, remarkable as it may seem, it does the work perfectly.

I hold in my hand a vial containing some "thermit," the wonderful properties of which were discovered by Goldschmidt. It consists of oxide of iron, such as one would get off a blacksmith's anvil or the rolls of a rolling-mill, mixed with powdered metallic aluminum. If a red-hot iron rod is thrown into this mixture nothing occurs; but by sprinkling a little barium preparation or some magnesium powder over the top of this mixture and applying a match immediately an extraordinary reaction takes place, producing a temperature of 5,400° F.; and if a kilo (2·2 pounds) of this substance is thus ignited the reaction which takes place

represents a mechanical equivalent of about 1,730 horse-power seconds, or about 1,274 kilowatt seconds.

I have here some samples of manganese, of chromium and ferro-titanium, all of which have been produced by this remarkable process; and I have seen some very interesting experiments in welding steel pipes, girder rails, etc., by means of this process.

It is claimed that a burglar might carry a small amount of thermit in his pocket, and on placing it on a steel safe would burn a hole through the safe, enabling him to insert his arm and extract the valuables. I myself have seen several safes which had thus been opened.

A company has been formed to exploit a substance known as "anti-thermit," which it is intended to mix with substances used as a heat-resisting lining of safes, and thus check any action of thermit.

It would be possible to insert a selenium cell in or near the safe so that the powerful light and heat produced by the burglar's attempt to open the safe in this manner with thermit, or even the light produced by his bull's-eye lantern, would affect the selenium cell and give an alarm to the police.

There are other applications of selenium for indication of the extinction of railway and ship signal-lights, and for various other purposes.

Those who are particularly interested in this subject I would refer to the paper of Mr. A. P. Saunders, in the *Journal of Physical Chemistry* for June, 1900, which, in addition to a large amount of valuable data, gives considerable of the bibliography regarding selenium.

SILOXICON, A NEW REFRACTORY MATERIAL.

E. G. Acheson, of Niagara Falls, N. Y., who discovered the process for making carborundum and that for making manufactured graphite, has discovered and patented a new compound to which he has given the name Siloxicon. It consists of carbon, silicon and oxygen, and if all the claims are supported it will be found that Siloxicon possesses physical and chemical properties of very great interest and importance to the field of metallurgy.

Siloxicon is the product of a new furnace that has been installed in the

plant of the International Acheson Graphite Works at Niagara Falls, N. Y. This furnace is about 30 feet long, 8 feet wide and is built to a height of about 6 feet when ready for operation. The raw materials used in the manufacture are ground coke and sand in proper mixture. One thousand electrical horse-power is applied to the furnace, and Siloxicon forms at a temperature ranging from 4,500° to 5,000°. With the present-size furnace the product is about 6 tons to a furnace. The walls of the furnace are of loose brick, no mortar being used in the building. The raw material is thrown into the furnace about a multiple set of flat cores, two or more in number. Siloxicon comes from the furnace in a loosely coherent mass and is then ground in a mill so as to pass through a No. 40 sieve, when it is ready for shipment in barrels.

Mr. Acheson describes Siloxicon as an amorphous gray-green compound when cold, and light yellow when heated to 300° F., or above; very refractory to heat, insoluble in molten iron, neutral toward basic and acid slags, indifferent to all acids save hydrofluoric, unattacked by hot alkaline solutions and self-binding to such a degree that the use of a separate binding agent is not essential in forming it into crucibles, furnace linings, fire-bricks and such other articles as may with advantage be made from it. The various articles may be formed by simply moistening the pulverulent material with water, molding and firing, or a carbonaceous or other binding agent may be used if desired. To-day the greater part of metallurgical operations are conducted with high-grade fire clays, but these have been improved upon by the use of chrome, silica and magnesia. However, the best of these fall short of perfect results, either on account of their low melting-point or the reaction that occurs between the slags. Siloxicon is insoluble in metal, infusible at high temperature and neutral to clays, thus forming an ideal material for metallurgical work. It is also unoxidizable. As Siloxicon is made at a temperature ranging from 4,500° to 5,000°, it is evident that it is capable of withstanding any heat produced by flame or fuel combustion. For this reason it is believed that Siloxicon will be a valuable lining where oil fuel is used, for at present under this intense heat trouble is experienced in getting something to withstand it. While Siloxicon is made in a furnace similar to carborundum, it forms previous to the carborundum formation. In the manufacture of carborundum some Siloxicon is formed, but it is found outside the carborundum core, where the heat of the furnace does not reach the higher temperature necessary to the manufacture of carborundum.—*Iron Age.*

ALCOHOL MOTORS.

Alcohol motors are much used in Germany, especially for automobile purposes, the fluid, 90 per cent. pure, being sold at about 5 cents per quart. The motors have all the advantages of cleanliness, ease of starting and stopping, and the weight is only about one-half that of a portable steam engine of equal power. Six to 8 horse-power motors are sold at about $140 per horse-power, 10 to 12 for about $115, and 16 to 20 for about $90 per unit of power. Tests seem to indicate an average consumption per brake horse-power per hour of about 0·92 pound of 86 per cent. spirit, and about 0·81 pound of a mixture of one-fifth benzol and four-fifths 86 per cent. spirit.—*Iron Age.*

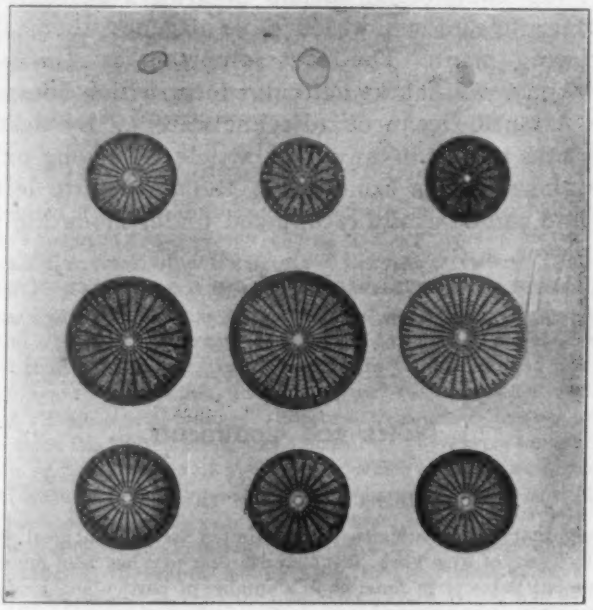
Section of Photography and Microscopy.

Stated Meeting, held April 4, 1903.

The Diatoms of Agar-Agar.

By Henry Leffmann.

Agar-agar, well known in the bacteriologic laboratory, is derived from several species of algæ growing in eastern Asiatic waters. It occurs usually in the form of filaments



Diatoms from agar-agar, prepared by Henry Leffmann; arranged and mounted by F. J. Keeley; photomicrograph by W. H. Walmsley.

about as thick as common straw. Its chief value to the bacteriologist is that it produces with water a jelly that does not melt at blood-heat, and can, therefore, be used for culture experiments at higher temperatures than can be used with common gelatin. It is analogous to the pectin of common fruits, and is not nitrogenous. It is used to a

limited extent as food, especially in the East, and is much employed in the large cities of the United States in the making of the cheaper ice-creams, especially the so-called "hokey-pokey" ice-cream sold by hucksters. It may also be used in some fruit jellies. It does not seem to be an objectionable article when used in moderate amount in these foods; in fact, as regards the ice-cream, the far more serious question is the liability of it to be made in dirty places and from dirty materials.

The detection of agar-agar itself when mixed with other vegetable or animal products would be difficult. Fortunately, the commercial article is always sprinkled with characteristic diatoms, which have attached themselves to the growing plant. The most important is *Arachnoidiscus Ehrenbergii*, a well-marked circular form, which does not live in the Atlantic Ocean or adjacent waters. By destroying the organic matter in any food article by strong oxidizing agents, the siliceous skeletons of the diatom are left uninjured, and can be easily recognized under moderate magnifying power.

A picture of forms obtained from a specimen of commercial agar-agar is appended.

Notes and Comments.

PRECIOUS STONES IN 1902.

A preliminary report submitted to the United States Geological Survey by Mr. G. F. Kunz, of New York, says that the year 1902 has been remarkable in precious-stone industry in America in a number of particulars, among which the following may be especially noted: The finding of a new locality for sapphires in Montana—a new creek, in the bed of which sapphires are found associated with gold, as in the Rock Creek region at Yogo Gulch, and on the Missouri near Helena; the further development of a new mine of blue sapphires in Fergus County; and the continued workings of the other two mines in the same State. Then comes the mining and development of the old beryl localities in Mitchell County, N. C., and the development of the beryl locality at Grafton, N. H. An amethyst mine has been opened in South Carolina, and two new amethyst deposits have been found in the State of Virginia. The mining of rubellite in San Diego County, Cal., continues, and a new deposit near Banner in the same region has been found. The further develop-

ment of chrysoprase in Tulare County, Cal., and the discovery of a new locality in Buncombe County, N. C., are to be noted. A deposit of vesuvianite (idocrase) has been discovered in Central California. The output of turquoise from eight or more Western localities continues, and it has been discovered at two localities in Alabama, the most easterly region yet known for that gem.

It has been the greatest year on record for the importation of diamonds, pearls and other precious stones. The imports, also, of topaz, both the true and the so-called Spanish, Saxon and Scotch varieties, of coral in delicate tints of pink, and of seed pearls and pearls in ropes, are worthy of remark.

The production of precious stones in the United States during 1902 is valued as follows: Sapphire, $115,000; beryl, $4,000; emerald, $1,000; tourmaline, $15,000; peridot, $500; quartz, $12,000; smoky quartz, $2,000; rose quartz, $200; amethyst, $2,000; gold quartz, $3,000; rutilated quartz, $100; agate, $1,000; moss agate, $500; chrysoprase, $10,000; silicified wood, $7,000; rhodolite, $1,500; garnet (pyrope), $1,000; amazon stone, $500; turquoise, $130,000; chlorastrolite, $4,000; mesolite, $1,000; pyrite, $3,000; anthracite ornaments, $2,000; catlinite (pipestone), $2,000.

This gives a preliminary total of $318,300 for 1902, as compared with $289,050 in 1901, and $233,170 in 1900.

SHIPBUILDING DURING 1902.

The returns of shipbuilding that are available for the year 1902 prove that although it has been a busy season among all the shipyards of the world, it does not reach in total output the figures of the year preceding. During 1902, 2,393 vessels of a total tonnage of 2,699,000 tons were launched, whereas in 1901, 2,192 vessels of 2,763,000 tons were launched, an increase in the number of vessels, but a decrease in the total tonnage of 64,000 tons. As usual, considerably more than half, in fact 60 per cent., of the world's output was built in British shipyards, from which, during the year, was launched a total of 1,368 vessels of 1,619,000 total tonnage. Next to Great Britain in amount of construction came the United States and Germany. There were launched in this country in 1902, 162 vessels of 315,000 tons, which is a decrease of 10,000 tons compared with the previous year. Germany launched 259 vessels of 272,000 tons, an increase during the year of 6,000 tons.

The prosperity of the shipping trade has been practically worldwide, the tonnage launched in France having risen from 32 vessels of 86,000 tons in 1901, to 102 vessels of 190,000 tons in 1902. Italy, Japan, and Holland all show a considerable increase. There is not much to be said regarding the character of the ships that were built, for there have been no radical changes either in the form of hull or in motive power. Perhaps the most interesting feature of the statistics is the increase in the number of sailing ships, the proportion of sailing to steam tonnage built in British yards having risen from 2·2 per cent. in 1900 to 3·9 per cent. in 1901, and 5·6 per cent. in 1902. Unquestionably the most interesting sailing ship of the year was the seven-masted schooner "Thomas W. Lawson." The steam turbine is not making the rapid advance in the mercantile marine that was expected, although it is being applied to a few passenger steamers and steam yachts. The most inter-

esting steamship of the year was, of course, the new North German Lloyd liner "Kaiser Wilhelm II," of 26,000 tons displacement and 24 knots speed.—*Scientific American.*

NEW TYPE OF FILE FOR GUN METAL.

A new type of file, specially devised for working upon gun metal, has been introduced into the engineering department of the Chemin de Fer du Nord, France. The feature of this tool, which distinguishes it from the general type of file, is a series of shallow channels which cross its face diagonally at an angle of 30° and placed about ½ inch apart. The raised portions of the surface of the file between these channels are occupied by the teeth of the tool. The advantages of the file are that it clogs less rapidly, and can easily and quickly be resharpened on the sand-blast, while it increases the work of the engineer who uses it in connection with gun metal filing by 30 per cent. —*Scientific American.*

NICKEL-STEEL ALLOY.

It was discovered some months ago that a nickel-steel alloy, containing 36 per cent. of the former metal, has a coefficient of expansion far below that of wrought-iron, it being only 0·0000005 for 1° F. It is also said to resist oxidation remarkably well. Recent investigations have shown the added fact that by the addition of small quantities of iron or nickel to the least expansive alloy it is possible to form an alloy having almost any desired coefficient of expansion. In this way "planite" is made, having the same coefficient as platinum, and also, of course, as glass. This new substance bids fair to supplant platinum (which has become far more expensive than gold) in the manufacture of incandescent lamps, where platinum terminals now pass through the glass.—*Iron Age.*

Book Notices.

Conductors for Electric Distribution: Their materials and manufacture, the calculation of circuits, pole-line construction, underground working and other uses. By F. A. C. Perrine, A.M., D.Sc., etc. 8vo, pp. viii + 287. New York: D. Van Nostrand Company. London: Crosby, Lockwood & Son. 1903. (Price, $3.50 net.)

The author presents in this work the clarified results of an experience of more than ten years as a manufacturer and consulting engineer. The fourteen chapters of the work appear to cover the subject in a most thorough manner. W.

Jahrbuch der Elektrochemie. Berichte über die Fortschritte des Jahres 1901. Herausgegeben von Dr. Heinrich Danneel. VIII Jahrgang, pp. viii + 725. Halle a/S. Verlag von Wilhelm Knapp. 1902. (RM. 24.)

The rapid progress of this branch of physical chemistry is amply certified by the imposing volume of more than 700 pages here entitled, in which is

concisely recorded the noteworthy discoveries and applications of the science which appeared during the year 1901.

The present volume follows in its arrangement of contents the general features of those which have preceded it.

Part I is devoted to the scientific side of the subject. It treats of methods and apparatus of research, theories, solutions, electrical energy, polarization and electrolysis, radiant energy and chemical energy. Part II treats of the applications of the science; the production of electrical energy by various types of generators; inorganic and organic electro-chemical products; apparatus employed in electrolytic and electrothermic processes. The volume closes with a review of books of the year and an elaborate index. W.

Einrichtungen von Elektrolytischen Laboratorien unter besonderer Berücksichtigung der Bedürfnisse für die Hüttenpraxis. Von H Nissenson. (Mit 32 in den Text gedruckten Abbildungen.) Halle a/S. Verlag von Wilhelm Knapp. 1903. (M. 2.40.)

Die Herstellung von Metallgegenständen auf Elektrolytischem Wege und die Elektrogravüre. Von Dr. W. Pfanhauser. (Mit 101 in den Text ged. Abbildungen.) Halle a/S. Verlag von Wilhelm Knapp. 1903. (M. 7.)

The works above named constitute respectively volumes IV and V of the series of "Monographien über angewandte Elektrochemie," which issue at regular intervals from the press of Wilhelm Knapp.

Vol. IV treats of the subject under two general heads. Part I takes into consideration the theory and principles of electrolysis, while Part II is devoted to the description of a number of noteworthy installations of electrolytic laboratories, principally in various educational institutions. These are accompanied by illustrations.

Vol. V treats of the methods employed in the galvanoplastic reproductions in metal, including the manufacture of metallic powders and the production of foils and tubes by electrolytic methods, and the present state of the art of electrogravure. W.

Elektrometallurgie des Nickels. Von Dr. W. Borchers. Mit vier in den Text ged. Abbildungen. 8vo, pp. 36. Halle a/S. Verlag von Wilhelm Knapp. 1903. (M. 1.50.)

Borchers' work treats not only of the electro-deposition of nickel on other metallic surfaces, but also of the electro-metallurgical separation and winning of nickel from its more or less complex ores. The latter phase of the subject is comparatively new and its treatment appears for the first time in book form. W.

Steam-Power Plants: Their design and construction. By Henry C. Meyer, Jr., M.E., 8vo, pp. 159. New York: McGraw Publishing Company. 1903. (Price, $2.00.)

The author explains that this book was written to give information to owners or managers of manufacturing plants or buildings requiring power installations, since they are from time to time called upon to specify or purchase the machinery needed for the proper equipment of their buildings with

a view to efficiency and economy in operation. While it is true wisdom to employ an expert to prepare plans and specifications for any important power-plant, it is also true that the greater number of steam installations will be made under the direction of men who are experienced in the details of manufacturing in their special lines, yet make no claim to expert knowledge in power-plant engineering. To such the author hopes that the information presented in his book will prove suggestive and valuable, as well as to the engineer, architect and student who desire general information on the subject treated.

To the expert it claims only to present in accessible and convenient form data useful in the practice of his profession. W.

Storage Battery Engineering: A practical treatise for engineers. By Lamar Lyndon, B.E., M.E., etc. 8vo, pp. vii + 382. New York: McGraw Publishing Company. 1903. (Price, $3 00.)

This is a practical work intended for the electrical engineer who is called on to design and install storage battery equipments, or who has a battery power plant under his care. The first part deals with the storage battery, its construction, action under various conditions, deterioration and the causes of the observed phenomena. The treatment is almost entirely physical, the chemical theory involved being very limited in extent and elementary in character. The second part covers all the apparatus, devices and methods used in the application and control of batteries. The various systems of boosters are described and an analytical discussion of each type is given. Some of the most important systems are illustrated by practical examples. Altogether it forms a complete compendium for the engineer to which any question that may arise in storage-battery practice may be referred and satisfactorily solved. W.

Franklin Institute.

[*Proceedings of the Stated Meeting held Wednesday, May 20, 1903.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, May 20, 1903.

President JOHN BIRKINBINE in the chair.

Present, 88 members and visitors.

Additions to membership since last meeting, 27.

The death of Mr. Theodore D. Rand, Vice-President of the Institute, was reported, with the action taken in connection therewith by the Board of Managers. An election was held to fill the vacancy, which resulted in the choice of Mr. James M. Dodge.

Mr. Howard W. DuBois, mining engineer, Philadelphia, presented a communication entitled "Reconnaissance Methods of Surveying in a Mountainous District." The speaker described and elucidated, by means of diagrammatic views, some new and interesting methods of applying photography for this purpose, and in addition to the technical illustrations, exhibited a series

of finely executed and artistically colored lantern photographs of the mountainous scenery of British Columbia.

Mr. Harrison Souder, Cambria Steel Company, Johnstown, Pa., followed with a paper on "Cuba of To-day: Engineering Notes and Impressions." The speaker gave an account of his observations made during a recent professional trip through the island, illustrating his remarks by showing a number of lantern photographs of interesting engineering works, mining operations and other subjects of general interest.

Dr. Samuel P. Sadtler followed with an informal discussion—principally from the chemical viewpoint—of the principles of the art of rendering wood, intended for structural uses, "fire-resistant," and commented on the results of a recent investigation of the Ferrell process by the Committee on Science and the Arts of the Institute. Dr. Sadtler's remarks were illustrated by the presentation of a series of samples of various building woods, treated and untreated, which had been subjected to compression and breaking tests by Mr. W. P. Taylor, Engineer-in-charge of the Municipal Laboratory. The interesting fact was brought out by those tests that the fire-proofing treatment by the Ferrell process did not appreciably impair the strength of the materials.

The thanks of the meeting were tendered to the speakers of the evening and the meeting was adjourned.

WM. H. WAHL,
Secretary.

Sections.

(*Abstracts of Stated Meetings.*)

MINING AND METALLURGICAL SECTION.—*Stated Meeting*, April 2d. Dr. E. Goldschmidt in the chair. Present, 54 members and visitors.

The Executive Committee announced the appointment of the following to serve as officers of the Section for the current year, viz.: President, James Christie; Vice-Presidents, Prof. F. L. Garrison and Wm. R. Webster; Secretary, G. H. Clamer; Conservator, Dr. Wahl.

The paper of the evening was presented by Mr. Clamer. Subject: "The Study of Alloys Suitable for Bearing Purposes." The author illustrated his remarks with the aid of a large number of photomicrographs and tables.

The discussion which followed was participated in by Messrs. Paul Kreuzpointner, A. E. Outerbridge, Jr., Robert Job and the author. (Paper and discussion will appear in the *Journal*.)

G. H. CLAMER,
Secretary.

PHOTOGRAPHIC AND MICROSCOPIC SECTION.—*Twenty-second Stated Meeting*, April 4th. Dr. Henry Leffmann in the chair. Present, 48 members and visitors.

Dr. Leffmann and Mr. F. J. Keeley presented a joint contribution on Agar-agar. Dr. Leffmann gave an account of the origin and uses of the plant, and Mr. Keely described and exhibited under the microscope the characteristic forms of diatoms found therein, by which it can be identified when used as a substitute for gelatin.

Mr. U. C. Wanner presented a communication on "Some Experiments in Stand or Tank Development," which was illustrated by the exhibition of a number of negatives and prints made from negatives developed in tanks with dilute developer.

Mr. Martin I. Wilbert addressed the meeting on "The Use of Lantern Slides as an Aid in Object Teaching." The speaker illustrated the subject by showing a number of slides (loaned by Prof. Jos. P. Remington) exhibiting botanic and pharmacologic objects colored by students of the St. Louis College of Pharmacy.

Mr. Howard W. DuBois exhibited a number of artistically colored slides and made some remarks on the method of coloring.

Dr. Leffmann exhibited a number of slides representing typical desert vegetation.

M. I. WILBERT,
Secretary.

PHYSICAL AND ELECTRICAL SECTIONS.—*Meeting*, Thursday, April 23d. Mr. Jesse Pawling, Jr., in the chair. Present, 22 members and visitors.

A paper entitled, "On the Design of Direct-Current Dynamo-Electric Machines," by Mr. Cecil P. Poole, of New York, was read by title and was ordered to be printed and circulated in advance of the next meeting for discussion. Dr. E. F. Roeber addressed the meeting on "Electrical Dissociation," which was announced as the subject for discussion. The following members participated, viz., Dr. E. Goldsmith, Prof. Amos P. Brown, Messrs. C. J. Reed, Carl Hering and C. H. Bedell. W.

SECTION OF PHOTOGRAPHY AND MICROSCOPY.—*Twenty-third Stated Meeting*, held Thursday, May 7, 1903. Dr. Henry Leffmann in the chair. Present, 49 members and visitors.

The first communication of the evening was a description and practical demonstration of the uses of platinum papers, by Mr. John Bradley. In the course of his demonstration the speaker developed a number of prints, illustrating the ease with which papers of this kind may be handled.

Dr. Henry Leffmann followed with a communication on "A Bacterial Lamp," which was an interesting abstract from a paper of Herr Malisch in a recent impression of the *Oesterreichische Chemiker Zeitung*.

Mr. J. W. Ridpath exhibited a number of miscellaneous lantern photographs of subjects of local interest.

M. I. WILBERT,
Secretary.

MINING AND METALLURGICAL SECTION.—*Stated Meeting*, Thursday, May 14, 1903. Mr. John Birkinbine in the chair. Present, 62 members and visitors.

The paper of the evening was presented by Mr. Charles Kirchhoff, Editor of the *Iron Age*, New York. Subject: "The Utilization of Blast Furnace Gases for the Generation of Power." The paper was fully illustrated by means of lantern photographs, and will appear in the *Journal* with discussion.

WM. H. WAHL,
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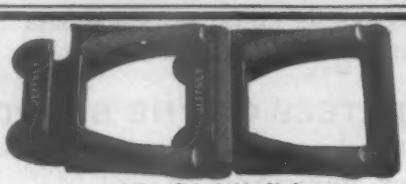

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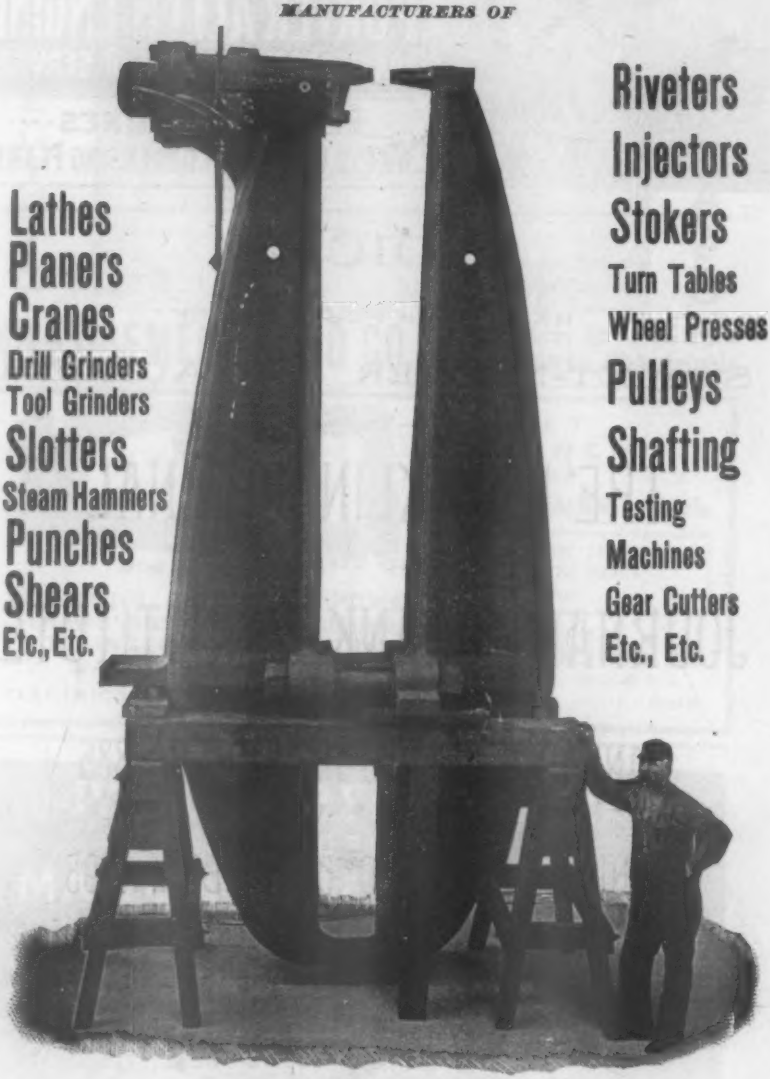

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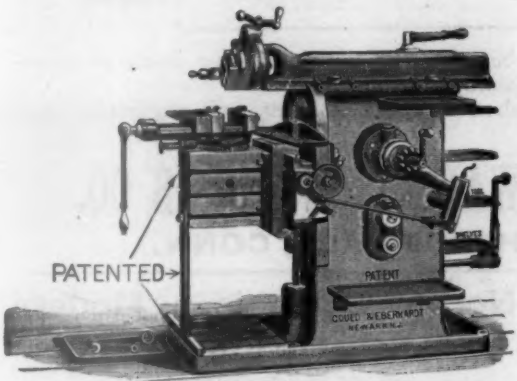

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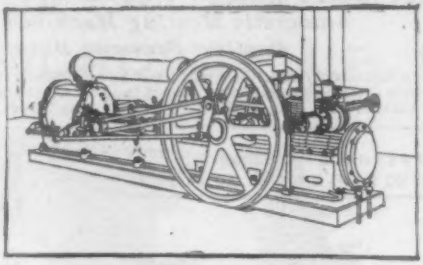

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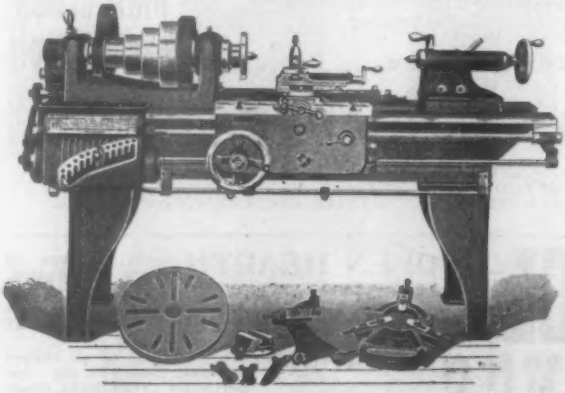

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APPENDIX A

Method of the International Association of Leather-Trades Chemists for the Analysis of Tanning Materials.

APPENDIX B

Method of Analysis of Tanning Materials of the American Association of Official Agricultural Chemists.

APPENDIX C

List of Coal-Tar Dyes Suitable for Dyeing and Staining Leather.

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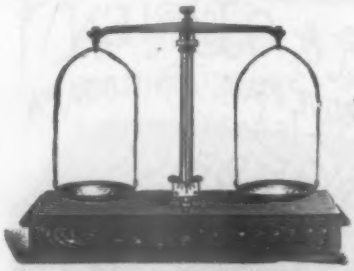

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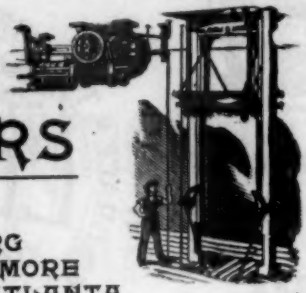

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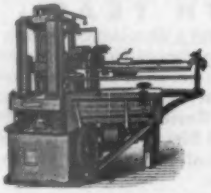

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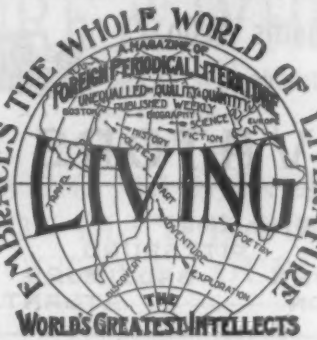

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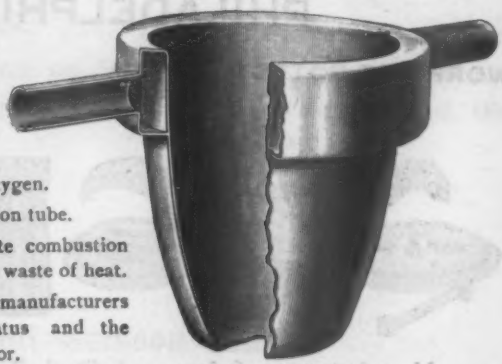

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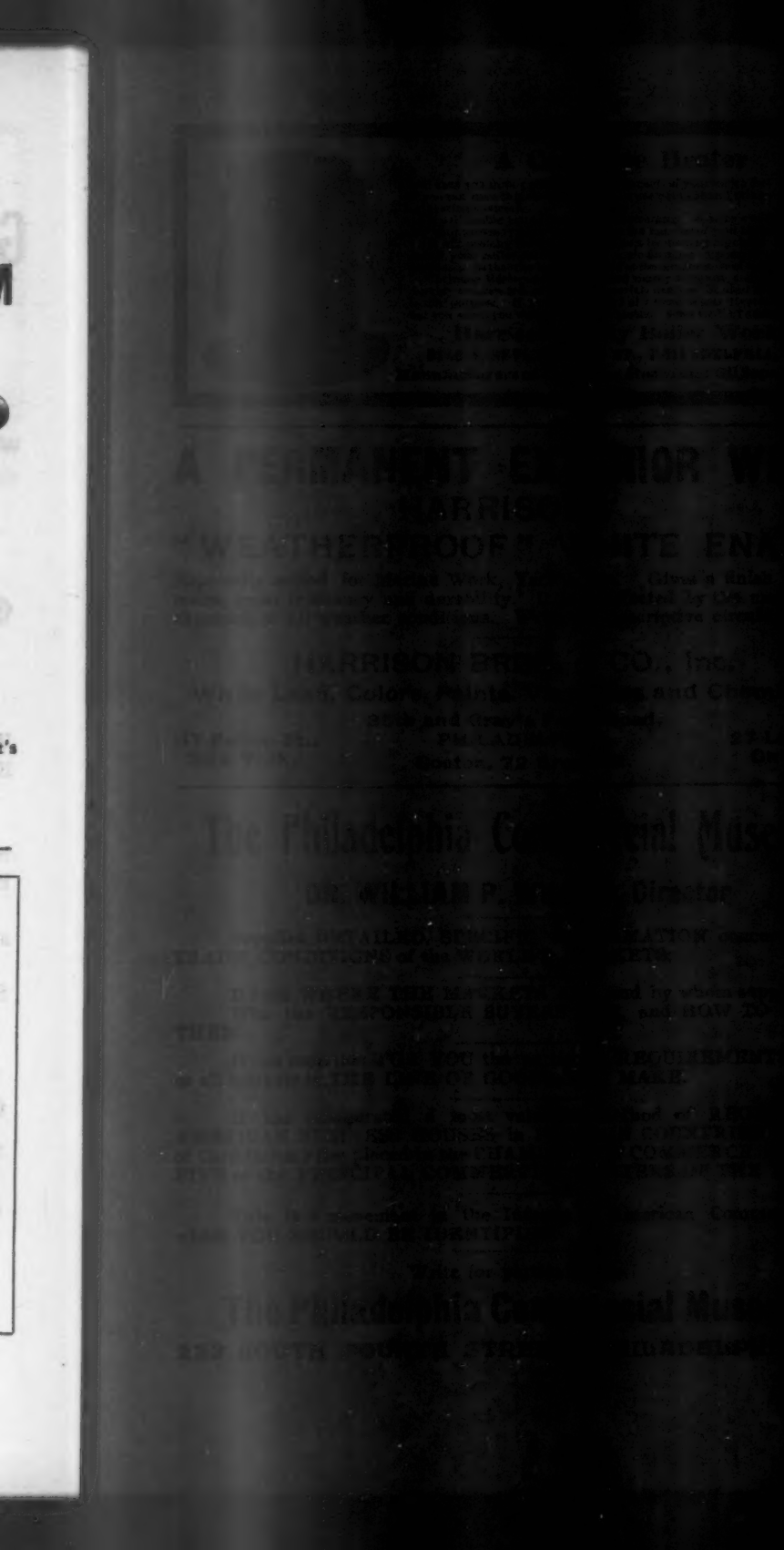
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